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ABSTRACT

The purposes of this study were (1) to ascertain the state of the art with regard to cost effectiveness and productivity analyses in education and (2) to develop an appropriate cost effectiveness analytical process model for education. Chapters I through III present a review of the literature on cost effectiveness analysis, cost benefit analysis, input-output analysis, and teacher effectiveness as a precondition to the development of a cost effectiveness model. To specify an analytical process model, the nine major generally recognized steps of cost effectiveness evaluations were examined. The general model and submodels representing each of the nine steps were specified in a network of flow diagrams showing the sequence of analytical operations and cause-effect relationships between elements. The general model classified the steps according to the three dimensions: cost, effectiveness/productivity, and integration of these two components. The submodels are: (1) specify the desired goals and objectives that the alternative educational programs are to fulfill; (2) distinguish the alternative programs; (3) specify evaluative criteria (measures) of effectiveness; (4) specify evaluative criteria (measures) of cost; (5) determine the cost of each alternative; (6) determine the effectiveness of each alternative; (7) display the results from cost and effectiveness determinations against the evaluative criteria; (8) merge cost and effectiveness information into a decision framework and document the merits of each alternative; (9) state the non-quantifiable and uncertainty factors. Steps of the general model were integrated with the conceptual framework of an educational system from a viewpoint of economic analysis. (RC)

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(Part 1 of 3 Parts)

an analytical process model for cost-effectiveness/ productivity evaluations of alternative educational programs

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JULY 1976

WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

TM006 018

Technical Report No. 390

(Part 1 of 3 Parts)

AN ANALYTICAL PROCESS MODEL FOR COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS OF ALTERNATIVE EDUCATIONAL PROGRAMS

by

Joseph J. Marinelli

Report from the Project on
Organization for Instruction and
Administrative Arrangements

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Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

July 1976

This Technical Report is a doctoral dissertation reporting research supported by the Wisconsin Research and Development Center for Cognitive Learning. Since it has been approved by a University Examining Committee, it has not been reviewed by the Center. It is published by the Center as a record of some of the Center's activities and as a service to the student. The bound original is in the University of Wisconsin Memorial Library.

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FUNDING

The Wisconsin R&D Center is supported with funds from the National Institute of Education; the Bureau of Education for the Handicapped, U.S. Office of Education; and the University of Wisconsin.

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ABSTRACT

AN ANALYTICAL PROCESS MODEL FOR
COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS
OF ALTERNATIVE EDUCATIONAL PROGRAMS

JOSEPH JOHN MARINELLI

Under the Supervision of Professor Richard A. Rossmiller

The purposes of this study were (1) to ascertain the state of the art with regard to cost-effectiveness and productivity analyses in education and (2) to develop an appropriate cost-effectiveness analytical process model for education.

Design of the Study

Specifications for the model required that it be integrated with a conceptual framework of formal education for economic analysis and that it conform to requirements drawn from (1) purposes of the study, (2) systems designs in general, (3) economic and systems theory and analyses, and (4) cost-effectiveness and productivity literature.

For purposes of this study, cost-effectiveness was defined as an economic and systems evaluation technique for comparing the productivity of pre-selected competing alternatives established for accomplishing some desired end, whereby the resource consumption and output, attributable only to each alternative, are integrated into a common decision framework.

Major Findings

Following review of the economic and systems framework within which cost-effectiveness evaluations operate, requirements for the model were stipulated from a discussion of the economic value, quantification, and costing of education, and techniques of economic and systems analysis related to efficiency and productivity. The cost-effectiveness review included a classification of the various applications (models) based upon different views of definition, role, analytical boundaries, research design, and procedures and specification of commonly recognized requirements. The review of productivity in education consisted of identifying and classifying input-output models of educational production, discussing analytical problems, and displaying the results of a number of studies in a manner consistent with the typology of inputs described in the educational system model adopted earlier.

To specify an analytical process model, the nine major generally recognized steps of cost-effectiveness evaluations were examined. This examination revealed the essential process elements and relationships within, boundaries of, and relationships between each step. The review included an examination of classifications of learning and objectives, curriculum descriptors, cost models and analyses, descriptive summary statistics, variables for selection for education production functions, and multivariate inferential statistical procedures. Some prescriptive guidelines and references were also provided for potential users of the model.

The general model and submodels representing each of the nine steps were specified in a network of flow diagrams showing the sequence of analytical operations and cause-effect relationships between process elements. The general model classifies the steps according to the three dimensions: cost, effectiveness/productivity, and integration of these two components. The submodels are:

1. Specify the desired goals and objectives that the alternative educational programs are to fulfill.
2. Distinguish the alternative programs.
3. Specify evaluative criteria (measures) of effectiveness.
4. Specify evaluative criteria (measures) of cost.
5. Determine the cost of each alternative.
6. Determine the effectiveness of each alternative.
7. Display the results from cost and effectiveness determinations against the evaluative criteria.
8. Merge cost and effectiveness information into a decision framework and document the merits of each alternative.
9. State the non-quantifiable and uncertainty factors.

Steps of the general model were integrated with the conceptual framework of an educational system from a viewpoint of economic analysis.

Implications

The prototype model developed in this research needs to be refined through the use of initial case studies and subsequent large scale field tryouts. It should provide practitioners with a methodology which can be employed to evaluate the productivity of Individually Guided Education and other educational programs and to provide feedback from the field

to program designers, implementors, and evaluators. An analytical process model of this type allows for research on direct applications of cost-effectiveness analysis to instructional programs and processes. Thus the systematic consideration of alternatives including new instructional methodologies should be advanced.

Approved by Richard A. Rossmiller
Richard A. Rossmiller

Date May 27, 1976

CHAPTER I

ECONOMIC AND SYSTEMS FRAMEWORK FOR COST-EFFECTIVENESS

In this chapter the economic and systems framework for cost-effectiveness analysis is examined. Support for utilization of cost-effectiveness analysis must rest on the concepts of economics and systems theory as they are applied to education. Thus, economic and systems concepts are basic. In this chapter the relevant concepts are reviewed. The chapter concludes with an introduction to cost-effectiveness analysis, thus providing a transition to Chapter II in which the literature on cost-effectiveness is reviewed to determine the state of the art and to develop the rationale for the research effort and model presented.

Historical Perspective of Economic Thought in Education

The development of economic thought concerning education can be traced to Smith[1] who viewed education as the basis of good civil government, economic activity, and progress. Ricardo and Malthus[2] viewed education as the means of inculcating habits which would cause a diminution of the population, thereby augmenting capital and increasing the economic well-being of the masses. For Mill,[3] education was a means for implanting habits of prudence, economy, and self-improvement. In his Principles of Economics, Marshall[4] referred to education as a national investment in which the economist has a direct interest, for he must address the principles on which the expense of educating children should be divided between the state and the parents. According to Vaizey[5] this historical linkage assigns a major role to publicly supported education, not only in promoting social peace and harmony and self-improvement, but also in the process of wealth creation itself. The widespread unemployment experienced in the 1930's apparently broke the train of economic reasoning about education, but as economic growth resumed in the 1940's, shortages of skilled talent became evident. Consequently, there developed a growing economic interest in "human capital."[6] As Johnson[7] observed, this development has affected economic thought about the worker and his wages, i.e., the laborer himself is a produced means of production, an item of capital goods.

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[1] John Vaizey, THE ECONOMICS OF EDUCATION, (Glencoe, IL: The Free Press, 1962), pp. 23-4.

[2] Ibid.

[3] Ibid.

The Growing Interest in the Economic Aspects of Education

O'Donoghue[8] cited three reasons for the growing interest in the economic aspects of education during the past decade: 1) the increase in the volume of activity which makes education one of the largest industries and one of the chief employers of highly skilled personnel, 2) the recognition that education may have a significant influence on the employment and income opportunities open to people and may affect the distribution of income and wealth in society, and 3) the post war emphasis on economic growth and development, with education playing an important role as the provider of skilled personnel for the economy.

---

[4] Alfred Marshall, PRINCIPLES OF ECONOMICS, (London: Macmillan, 1908), p. 217.

[5] Vaizey, ECONOMICS OF EDUCATION, pp. 23-4.

[6] *Ibid*., p. 25.

[7] Harry G. Johnson, "The Political Economy of Opulence," CANADIAN JOURNAL OF ECONOMICS AND POLITICAL SCIENCE, 26 (November, 1960), 562.

[8] Martin O'Donoghue, ECONOMIC DIMENSIONS IN EDUCATION, (Chicago: Aldine-Atherton, 1971), p. 1.

Data provided by the National Educational Association[9] reveal that a significant portion of the economic resources of the United States are allocated to education. In 1969-1970, educational institutions as major users of economic resources spent $66.8 billion and employed six million persons. Public elementary and secondary schools alone expended $39.5 billion and employed over three million persons. It is little wonder that in recent years education has attracted the attention of a number of economists.

Levin[10] and others reviewed numerous research studies of the relationship between school achievement and post-school success. Although, as these studies indicate, there are obstacles to systematic verification of a cause-effect relationship, education and opportunity are linked in complex ways. An abundance of evidence supports the view that education affects income, occupational choice, and economic mobility.

---

[9] Research Division, National Educational Association, FINANCIAL STATUS OF THE PUBLIC SCHOOLS, 1970, (Washington, D.C.: NEA, 1970), pp. 18, 31.

[10] Henry M. Levin, et al., "School Achievement and Post-School Success," REVIEW OF EDUCATIONAL RESEARCH, 41 (February, 1971), 1-16.

Schultz[11] sparked the interest in evaluating human capital when he postulated that all economic growth could not be explained by the conventional factors of land (natural resources), labor (human services), and capital (produced means of production) alone. Education as a form of human capital is based on the notion that skills and knowledge possessed by people are, in fact, resources, and that human resources represent a very important part of the capital available to society. Bowman[12] pointed out the limitations of the work of Schultz, Dennison, and others by suggesting that the results were predetermined in the sense that there was no independent validation of the implicit hypotheses concerning contributions by education, or other factors, to economic growth. What Schultz and Dennison tested was the validity and significance of highly aggregated factors--variables in association with education, such as students' ability--in the explanation of economic growth. Although education may not be the overwhelming element in accounting for the early "residuals," the findings suggest that aggregative factors in relation to education, not merely the "micro returns" to education, are important. When it was discovered that over half of the annual economic growth of western countries after World War II was an unexplained "residual," education was accorded the honor for the unexplained growth. Bowman asserted that, "despite almost fifteen years of efforts to account for this residual, and some sucess in paring it down, the proportion of growth unexplained remains high" and that "economics still lacks an even approximately adequate theoretical framework for dealing with the truly dynamic elements in rapid and sustained economic growth."[13]

---

[11] Theodore W. Schultz, THE ECONOMIC VALUE OF EDUCATION, (New York: Columbia University Press, 1963), pp. x-xi.

[12] Mary Jean Bowman, "Education and Economic Growth," in ECONOMIC FACTORS AFFECTING THE FINANCING OF EDUCATION, Roe L. Johns, Irving J. Goffman, Kern Alexander, and Dewey H. Stollar, eds., (Gainesville, FL: National Educational Finance Project, 1970), pp. 90-95.

In a self-regulating market economy questions related to the allocation of resources are answered by the market itself. But in the public sector,

> the need to become explicit arises from the fact that in all countries a whole range of governmental services are normally supplied without prices being charged for them; even if the inputs into the public services are purchased in markets, the output is not sold in markets and, furthermore, the service in question may not be produced at all by the private sector.[14]

Due to the lack of a self-regulating market system in education and the need to allocate scarce resources to and within education, several economic decision models for educational planning exist which, according to Benson,[15] seek to answer the following questions: What kinds of goods are to be provided? What amounts of various goods are to be produced? How are resources to be combined in efficient schemes of production? How is the total economic product to be shared among households? At what level are various kinds of improvements in the economy to be sought? Musgrave[16] identified two classes of goods which are satisfied through the public sector of the economy, social goods and merit goods. He viewed education as a merit good--one which could be provided through the market, but which is deemed to be essential to the general welfare of a democratic society to chance its being undersupplied through the market. Secondly, education provides social benefits, labeled as externalities or spillovers, beyond those which accrue to the individual. It is for these reasons that the market does not control the allocation of resources to education and, therefore, the need exists for educational planning.

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[13] Ibid., p. 90.

[14] Mark Blaug, AN INTRODUCTION TO THE ECONOMICS OF EDUCATION, (Middlesex, England: Penguin Books, 1970), p. 120.

[15] Charles S. Benson, THE ECONOMICS OF PUBLIC EDUCATION, (Boston: Houghton Mifflin, 1968), p. 19.

Economic Approaches to Educational Planning

Education may be viewed as a personal investment made by people because it raises income or lowers costs,[17] or fulfills the manpower requirements of society.[18] In fulfilling the manpower requirements of society, the distribution of the labor force by level of schooling is computed from the distribution of workers by occupation. Education also may be viewed as a social investment in which other sectors of a community may experience economic side effects (externalities) from the education obtained by some of its members.[19]

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[16] Richard A. Musgrave, THE THEORY OF PUBLIC FINANCE, (New York: McGraw-Hill, 1959), pp. 6-15.

[17] O'Donoghue, ECONOMIC DIMENSIONS, pp. 42-75.

[18] *Ibid.*, pp. 118-47; Samuel S. Bowles, PLANNING EDUCATIONAL SYSTEMS FOR ECONOMIC GROWTH, (Cambridge, MA: Harvard University Press, 1969), pp. 141-52.

The effects of decisions on the provision of education potentially permeate the entire society which recognizes that education entails subsidiary as well as direct consequences.[20] Therefore, the function of investing in human capital increases the economic productivity of the individual who, in turn, is rewarded by receiving a higher return for his services. By increasing the knowledge and skills of the individual, education tends to increase potential earnings. In addition, some of the private benefits involve such things as the increased satisfaction in future years which may be derived from past and continuing exposure to new ideas and cultural opportunities. As Hirsch[21] and others have pointed out, because of the difficulties of quantifying non-market or consumption aspects of education, studies typically ignore any benefits which are either not directly valued in the market or which are not measured at least indirectly through market counterparts.

The external benefits of education are both economic and social in nature. Education ultimately may affect the productivity of individuals other than direct recipients, and it can affect expenditures for other services made necessary by a lack of education. Education may also affect both the acceptance of social values, and the feasibility of accomplishing social goals.[22] Education can be viewed as involving both consumption and investment components. As private consumption, people value education for its intrinsic worth and are willing to spend money to obtain their education. As public consumption, the public decides to spend money for education rather than for other public services. As investment, people or the state consciously and deliberately invest in themselves or in their children.[23]

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[19] O'Donoghue, ECONOMIC DIMENSIONS, pp. 76-100.

[20] Ronnie J. Davis, "The Social and Economic Externalities of Education," in ECONOMIC FACTORS AFFECTING THE FINANCING OF EDUCATION, Johns, et al., eds., pp. 62-63.

[21] Werner Z. Hirsch, Elbert W. Segelhorst, and Morton J. Maraus, SPILLOVER OF EDUCATION COSTS AND BENEFITS, (Los Angeles: Institute of Government and Public Affairs of University of California at Los Angeles, 1964), p. 317.

Blaug[24] criticized the emphasis placed on the notion of externalities and spillovers. He suggested that it is a myth to view the indirect social benefits of education as vastly exceeding the direct personal benefits to the "educatees." It is asserted to be a myth because the literature is virtually void of any evidence to support the claim and because there is a great confusion with regard to what is meant by externalities or spillovers in education.

The Economic Value of Education

The question of how much an individual is willing to invest in education may hinge on the results obtained from two approaches to ascertaining the dollar value of education; namely, present value and rate-of-return analyses. Present value analysis identifies and determines the

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[22] Davis, FINANCING OF EDUCATION, pp. 64-68.

[23] Vaizey, ECONOMICS OF EDUCATION, pp. 26-27.

[24] Blaug, INTRODUCTION TO THE ECONOMICS, pp. 107-8.

the present value of one's lifetime earning stream. As a general rule, outputs are the additional earnings due to schooling and inputs are the direct costs of increments of schooling plus the opportunity costs incurred, i.e., earnings for one while in school. The present value of the stream of costs for reaching a given income is subtracted from the present value of the stream of future income. Hence, the criterion for investment in education is a value greater than zero.

Rate of return analysis typically is used to support investment in education or investment at different levels of education as opposed to other investments. It simply compares the internal rate-of-return from various alternatives, i.e., the difference between the value of a stream of costs and the value of a stream of income for each alternative investment.

Mathematically, the present value of an income of Y dollars per year for n years beginning with year t = 1 is

$$V_o(Y) = \sum_{t=1}^{t=n} \frac{Y_t}{(1+i)^t} \qquad ;\ i = \text{rate of interest}$$

The present value of a stream of costs of X dollars per year for n years beginning with year t = 1 is

$$V_o(X) = \sum_{t=1}^{t=n} \frac{X_t}{(1+i)^t}$$

Therefore, the internal rate-of-return for comparing alternatives is

$$V_o(Y) - V_o(X) = \sum_{t=1}^{t=n} \frac{Y_t}{(1+i)^t} - \sum_{t=1}^{t=n} \frac{X_t}{(1+i)^t}$$ [25]

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[25] J. Alan Thomas, THE PRODUCTIVE SCHOOL: A SYSTEMS ANALYSIS APPROACH TO EDUCATIONAL ADMINISTRATION, (New York: Wiley, 1971), pp. 22-29.

A central economic concept in educational planning and finance is the rate-of-return to investment, a concept which has a firm foundation in economic theory and which is applicable to both public and private decision concerning the allocation of resources. Schultz[26] estimated the private rates-of-return for the United States economy and for investment in education at various levels of schooling but admitted the difficulty of estimating the social rates-of-return which are, in general, thought to be similar to the private rates-of-return. He concluded that there exists an under investment in elementary education, and that associated with this under investment is neglect of quality in schooling which extends into secondary and even higher education. Related to the problem of investment is the problem of determining the most efficient level of investment in education. But the most efficient combination of school (resource) inputs and the amount of inputs required to move to an optimum quality of schooling still is conjecture, for this question has not yet been subject to the requisite measurement and evaluation which are long overdue.[27]

Educational Costs

The general concept of cost is another important contribution of economics to education. Costs are not synonymous with expenditures, for costs include the "opportunity costs," defined by Bowman as,

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[26] Schultz, FINANCING OF EDUCATION, pp. 47-50.

[27] Ibid., p. 52.

> . . .what the individual or group or society gives up . . . in making this choice. Here costs are defined in terms of "what is given up" rather than "what is put in."[28]

Translated into an educational framework, when individuals who otherwise would be in the labor force are in school, their productive services are withdrawn from the economy, and they themselves forego earnings. Relative to internal time allocation, foregone earning might well be viewed as foregone learning, which implies that

> . . .the cost of a given curriculum or of a given instructional procedure is measured in part by foregone opportunities to devote students' and teachers' time to other curricula and procedures.[29]

Schultz[30] emphasized that school expenditures alone are not appropriate for the purpose of ascertaining all of the costs involved in education because school expenditures do not include all costs incurred in schooling. Total factor costs must encompass all annual costs of schooling, including expenditure supported from school and other taxes or tuition, earnings foregone, taxes or gifts and profits foregone, costs borne directly by the student and his family, and costs not borne directly by the student and his family.

Thomas[31] provided a useful categorization of educational costs: direct and indirect, social and private, and monetary and non-monetary.

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[28] Mary J. Bowman, "The Costing of Human Resource Development," in ECONOMICS OF EDUCATION, E. A. G. Robinson and J. E. Vaizey, eds., (New York: St. Martin's, 1966), pp. 422-23.

[29] Thomas, THE PRODUCTIVE SCHOOL, p. 32.

[30] Schultz, ECONOMIC VALUE OF EDUCATION, p. 21.

[31] Thomas, THE PRODUCTIVE SCHOOL, pp. 34-35.

Direct costs entail monetary outlays for instructional, non-instructional and administrative personnel as well as for facilities, equipment, materials, supplies, etc. Direct costs usually are included in the educational budget as purchases of human and material resource inputs. Indirect costs include depreciation and obsolescence, imputed interest on invested capital, property and sales tax exemptions granted to educational institutions, and students' foregone earnings.

Household units bear the burden of private costs by paying tuition and fees, and by foregone earnings and loss of leisure. Social costs include private costs and those which are shared by the public through revenue collected by taxation or through gifts or bequests. Public monies approximate the total outlay of resources in public elementary school, whereas, although private institutions may receive some public subsidies, the student pays a considerable percentage of the total direct cost in private elementary schools.

Costs which are direct or indirect and are paid by society or the individual may be monetary, whereas non-monetary costs within a school include the opportunity cost associated with the allocation of time.

Concern with Quantification and Measurement

Economists are concerned with quantitative results and, consequently, seek measurements of the phenomena they investigate. This emphasis on measurable phenomena arises from the nature of economics itself, which is concerned with the manner in which choices concerning the allocation of scarce resources are made. Economists seek to measure the annual flow of inputs for education--the services of personnel, such as, teachers, librarians, and school administrators, and the annual factor costs of maintaining and operating the school plant, such as, depreciation, obsolescence, and interest--but excluding expenditures to operate auxiliary enterprises (school lunch, athletics, etc.), and expenditures for transfer payments, such as, scholarships and other financial aids.[32]

Rossmiller[33] discussed the concerns of the staff of the National Educational Finance Project with regard to the question of what constitutes the product (or output) of education. The output of most enterprises is tangible, concrete, and short-lived but the output of education often is intangible, abstract, and long-lived. It is an assumption of the market model that one's decision concerning whether or not to buy or invest depends on what one anticipates in return for that investment. It is difficult, however, to assess the utility of knowledge gained in school during the learning process itself, for the ultimate test of the utility of the knowledge will occur at some time in the future. In addition, most evaluations of the output of schooling fail to take account of the affective dimension of learning which, in part, determines the attitudes, values, and beliefs acquired as a result of the educational process. Traditionally, school output has been quantified primarily by testing for evidence that certain cognitive knowledge has been acquired.

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[32] Schultz, ECONOMIC VALUE OF EDUCATION, p. 22.

[33] Richard A. Rossmiller, "Economics and the Financing of Education," in FINANCING EDUCATION, Roe L. Johns, Kern Alexander, K. Forbis Jordan, eds., (Columbus, OH: Merrill, 1972), pp. 53-54.

But

> . . .there are few outcomes of the schools that are measured systematically. While some achievement data from paper and pencil testing are available, even these are not adjusted for differences in performance due to student backgrounds and other non-school influences. Thus, they are of little operational value in assessing the schools' effects on achievement. Moreover, such tests measure such a limited range of outcomes, that even if they were useful on their own terms, they would not be appropriate as exclusive foci for school policy. Indicators of student attitudes, feelings, cultural aptitudes, and other skills that might be developed by the schools are not obtained in any regular and systematic way.[34]

Efficiency and Productivity

A further question of considerable importance from an economic viewpoint concerns the efficiency with which the resources allocated to education are utilized.[35] The general question of efficiency in public expenditure is one which, after decades of comparative neglect, recently has received considerable attention from economists. An examination of the recent literature which is replete with such terms as program budgeting, cost-effectiveness, cost-benefit, systems analysis, efficiency auditing, and similar phrases suggests that a variety of methods have been developed for the treatment of this question. The differences in nomenclature, however, refer primarily to the scale or the context within which a particular problem is being attacked, and should not be allowed to mask the underlying unity in the basic approach. Essentially, the approach is one which seeks to identify the outputs of each program as they relate to the objectives of that program, and then to determine the cost patterns associated with the attainment of these outputs. It is important to emphasize that, in this context, efficiency is conceived in terms of minimization of cost for an appropriately defined output and should not be confused with cost minimization in an absolute sense. Movement toward identification of objectives in output terms might be accomplished by specifying some measure of pupil attainment. Such an attainment measure will call for the specification of alternative curricula and for evaluation of pupils' performance for each alternative curriculum. To evaluate efficiency, it is necessary to specify the range of pupil achievement which is acceptable. The central principle of educational planning for maximum efficiency is to maximize the return from a given amount of resources devoted to education, or alternatively expressed, to produce at the lowest possible cost that level of educational output which is chosen as desirable.

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[34] Henry M. Levin, "The Effect of Different Levels of Expenditures on Educational Output," in ECONOMIC FACTORS AFFECTING THE FINANCING OF EDUCATION, Johns, *et al*., eds., p. 180.

[35] Blaug, INTRODUCTION TO THE ECONOMICS, pp. 266-69.

Knowledge of the relation between inputs (i.e., allocated resources) and outputs, as conventionally measured by achievement scores, is an essential part of a planning approach to education. Without knowledge of the educational production process, one is not able to estimate the relative effectiveness of each factor input per unit of cost; nor can one compare the relative productivity of resources devoted to the attainment of different types of educational objectives.

Production Functions

The concept of a production function in education has been discussed by Vaizey,[36] Bowles,[37] Blaug,[38] and Thomas.[39] To achieve maximum efficiency, a school or school district must obtain the maximum possible educational output within the limits of its budget. An educational production function conceptually depicts a relationship between the maximum amount of educational output that could be obtained from each and every set of specified inputs or factors of production. A productive organization is one which obtains a favorable balance between outputs and inputs. The mathematical relationship between outputs and inputs can be expressed as an equation called a production function.

Production in education may be viewed in a number of ways. Thomas[40] conceptualized three models of input-output relationships in education: the administrator's production function, the psychologist's production function, and the economist's production function. In the administrator's production function, quality is a function of the quality and quantity of inputs (people and goods) and outputs are units of specific services. Input quality is related to program cost where program cost and program quality are assumed to be identical. Computation in this model is an accounting procedure.

The psychologist's production function treats inputs and outputs as variables. Inputs are related to changes or increments in student achievement, i.e., outputs are cognitive and affective behavioral changes of students, e.g., value-added by schooling. The methodology employed is multivariate statistical analysis using multiple regression procedures.

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[36] Vaizey, ECONOMICS OF EDUCATION, pp. 77-88.

[37] Bowles, PLANNING EDUCATIONAL SYSTEMS, pp. 82-94.

[38] Blaug, INTRODUCTION TO THE ECONOMICS, pp. 269-81.

[39] Thomas, THE PRODUCTIVE SCHOOL, pp. 9-30.

[40] Ibid., pp. 9-30.

The economist's production function views the productive school as balancing the monetary value of the education that individual pupils receive with the cost of providing that education. Inputs are the cost of a particular increment of schooling and output is the additional earnings which result from that increment. Analytic techniques used in this approach include the present value and rate-of-return procedures, as discussed earlier on pages 9-10.

Thomas viewed production functions in terms of the principal users, that is, the administrator, psychologist or economist. Levin,[41] as illustrated by the two formulas below, conceptualized two functions in terms of the type of input-output linkages to be examined. Equation (1) represents a production function for an educational system where A signifies a measure of educational outcomes, B denotes the nature of the student clientele, and $X_1, X_2, \ldots X_n$ represent a set of inputs or resources used by schools to produce educational outcomes:

$$(1) \quad A = f\,(B, X_1, X_2, \ldots X_n)$$

This equation is essentially synonymous with Thomas' psychologist's production function.

Cohn[42] distinguished implicit from explicit general production functions on the basis of their underlying assumptions. Implicit production functions assume unidimensionality and measurability of output and knowledge and quantifiability of relevant inputs. The function is implicit since the relationship of how each of the input variables influence output is not specified. An explicit function will make such a specification. Equation (1) above is implicit, but equation (2) below is explicit since it assumes additivity.

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[41] Levin, FINANCING OF EDUCATION, pp. 176-78.

[42] Elcahan Cohn, THE ECONOMICS OF EDUCATION, (Lexington, MA: Heath, 1972), pp. 237-38, 257.

Levin's second equation which follows depicts the relationship between the dollar budget accorded educational decision makers and the allocation of that budget to various school inputs:

$$(2) \quad R = P_1X_1 + P_2X_2 + \ldots + P_nX_n$$

In this equation, R represents the total dollar expenditure or budget allocated to an educational system; P_1 signifies the price per unit of input X_1; P_2 is the price per unit of input X_2, etc. The budget equation can be interpreted to mean that the dollar allocation R will be utilized to purchase inputs $(X_1, X_2, \ldots X_n)$, where the expenditure on each input is defined by the amount of each input used multiplied by its price. The quantity and quality of each input to be purchased would be determined by the amount which may be expended and the contribution each input makes toward the desired outputs.

An optimal allocation of resources requires that a set of inputs be so manipulated until the assumed output is maximized. The optimization of some "objective function," however, is subject to a system of constraints, such as a fixed average daily school attendance, the total budget, the specification of a range of assignments per teacher, teaching load, number of units offered, student-teacher ratio, or teacher salaries.[43] Inputs should be purchased and utilized in such a manner that the additional contribution to output from the last dollar expended on each input yields the same effect on output. It is at this point that dollar expenditures are allocated most effectively. That is

> . . . if an additional dollar spent on X_1, yields a greater contribution to output than one spent on X_2, then more X_1 should be applied to producing education and less X_2 should be used. The law of diminishing marginal returns suggests that an increase in the use of X_1 will be accompanied by a decline in the rate of increase in A due to more X_1, so at some point the marginal or additional impact of X_1 on A relative to that of X_2 on A will be equal for the last dollar spent on each.[44]

This area of concern in economics is known as marginal productivity and is described in equation (3).

$$(3) \qquad \frac{\text{Additional output from } X_1}{P_1} = \frac{\text{Additional output from } X_2}{P_2} = \ldots = \frac{\text{Additional output from } X_n}{P_n}$$

The additional output from each input relative to its price should be equal for all inputs. The solution is intended to maximize the effectiveness of the budget in producing output.

Levels of Efficiency

It is useful at this point to distinguish between technical and allocative efficiency[45] (see Figure 1.1). The most productive mix with regard to technical efficiency refers to the linkage of education output (A) and equation (1): $A = F(B, X_1, X_2, \ldots, X_n)$. This equation provides for maximization of output for a specified set of inputs. That is, there exists a way of organizing a set of staff personnel, materials, facilities, and program content and process that will maximize a school's educational output.

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[43] Ibid., pp. 260-61.

[44] Levin, FINANCING OF EDUCATION, p. 178.

Allocative efficiency occurs when the amount and kind of resources purchased within a given budget constraint yield the greatest output that can be attained for the given budget; any other combination of resources that could be purchased with that budget would yield a lower level of output. If equation (3) is satisfied, schools are said to be allocatively efficient.

Sources of Inefficiency

The criterion of efficiency generally does not appear to be satisfied in contemporary school operations. Schultz[46] attributed the lack of efficiency in schools to several factors:

(1) There is a dearth of research on the amount of students' time put into formal education as an important input variable.

(2) There has been very little substitution of material resources for human resources as in other sectors of the economy in light of the sharp rise in the price for material input.

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[45] *Ibid.*, p. 183.

[46] Schultz, ECONOMIC VALUE OF EDUCATION, pp. 40-47.

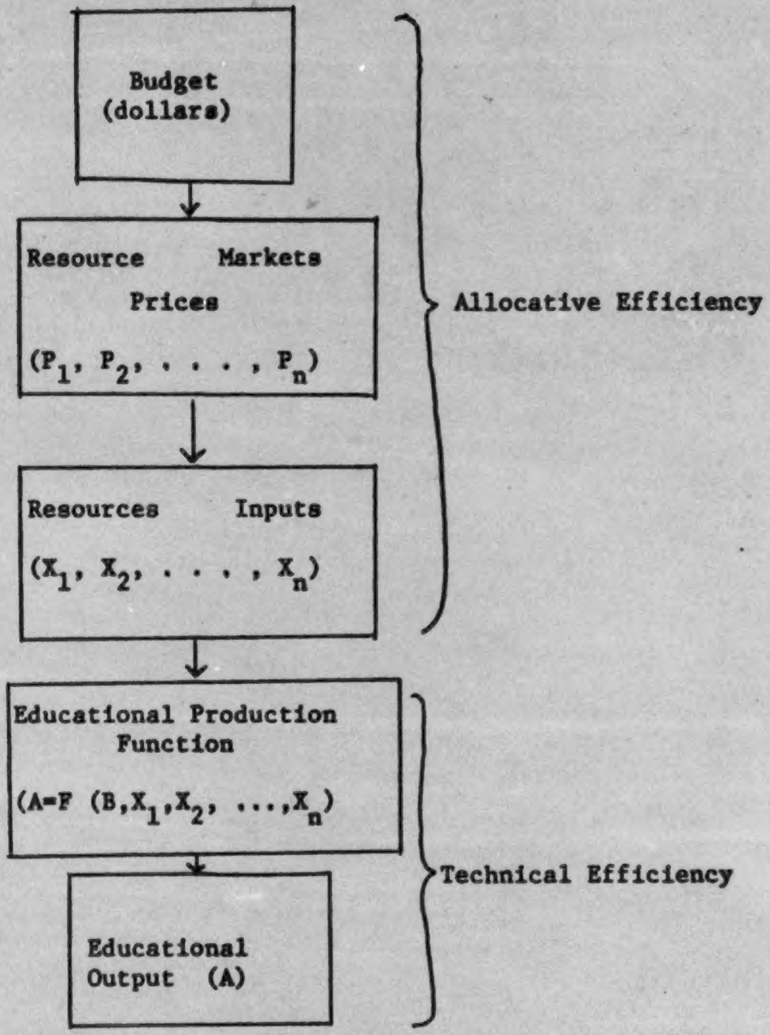
Budget
(dollars)
Resource Markets
Prices
$(P_1, P_2, \ldots, P_n)$
Resources Inputs
$(X_1, X_2, \ldots, X_n)$
Educational Production Function
$(A=F\ (B, X_1, X_2, \ldots, X_n)$
Educational Output (A)
Allocative Efficiency
Technical Efficiency

Figure 1.1--Flow Diagram of Educational Resource Transformation

Source: Henry M. Levin, "The Effect of Different Levels of Expenditures on Educational Output," in ECONOMIC FACTORS AFFECTING THE FINANCING OF EDUCATION, Roe L. Johns, Irving J. Goffman, Kern Alexander, and Dewey H. Stollar, eds., (Gainesville, FL: National Educational Finance Project, 1970), p. 179.

(3) If the returns from education are high, then efforts should be directed mostly toward career education.

(4) Education is slow to adjust to price levels and employment needs, i.e., education relies on a stable property tax whereas the goods and services purchased by education are purchased during fluctuating economic periods.

Levin[47] attributed inefficiency to:

(1) state education codes, regional accreditation requirements, contracts with educational personnel and an inbred reverence for existing practices which bind administrators;

(2) the lack of systematic and effective measurement of cognitive achievement and the lack of measurement of affective achievement;

(3) school accounting systems which are unable to link the ingredients of particular programs or the programs themselves to either costs or outcomes;

(4) the nonexistence of incentives for maximizing educational outcomes for a given budget due to the reward system for school personnel;

(5) student assignment practices which are based on bookkeeping traditions instead of on educational rationale such as the structure of the classroom situation;

(6) the improper integration of innovational equipment and curricula into the school organization;

(7) the uniformity of practice for each student; and

(8) the purchase of inputs which are based on conventional wisdoms due to the lack of knowledge about the effect of inputs on outputs.

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[47] Levin, FINANCING OF EDUCATION, pp. 180-83.

Haggerty[48] pointed out the general trend toward reduction in productivity in the educational sector. Reducing class size has not been proven to give greater output; therefore, education is becoming less efficient. This situation points to the need for quota efficiency to increase educational productivity quantitatively and/or qualitatively.

Approaches to Improving the Effectiveness of the Educational Dollar

Several approaches to improving the effectiveness of the educational dollar have been suggested, among them the development of information systems, creating alternatives to traditional schooling, accountability, and systems analysis.

Information Systems

The availability of information systems[49] which provide the data needed to evaluate and make decisions is crucial in any systematic attempt to evaluate the effectiveness with which educational dollars are used. Although most schools maintain a plethora of records, too frequently the records do not provide the data needed and too often the data which do exist are not readily accessible. Schools need timely and accurate information about their own operations and performance in a form which can be directly implemented in decision making. This information can be gained by evaluating the outcomes of existing programs as well as linking costs to particular programs. Communicating to decision makers the priorities of various clienteles of the schools and keeping abreast of emerging educational technologies also are necessary elements to improve decision making by utilizing the capabilities of information systems properly. It is through the establishment and utilization of an information system that a foundation for any systems analysis technique is established.

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[48] Patrick E. Haggerty, "Research and Development, Educational Productivity and the American Economy," AMERICAN EDUCATIONAL RESEARCH JOURNAL, 10 (September, 1973), 4-10.

[49] Levin, FINANCING OF EDUCATION, pp. 194-95.

> The need for information is an essential aspect of open systems theory. Systems exist in constant interaction with their environment. The environment is in a state of change, and systems which do not possess information retrieving procedures are not able to adapt to environmental change.[50]

Accountability

Barro has identified four "current thoughts and actions" which have come about as a result of the public's demand that schools and educators be held responsible for the results they are producing:[51]

> (1) The new federally stimulated emphasis on evaluation of school systems and their programs;
>
> (2) The growing tendency to look at education enterprises in terms of cost-effectiveness;
>
> (3) Increasing concentration on education for the disadvantaged as a priority for the schools; and
>
> (4) The movement to make school systems more directly responsive to their clientele and communities, either by establishing decentralized community control or by introducing consumer choice through a voucher system.

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[50] Thomas, THE PRODUCTIVE SCHOOL, p. 104.

[51] Stephen M. Barro, "An Approach to Developing Accountability Measures for Public Schools," PHI DELTA KAPPAN, LXII (December, 1970), 196.

Although educators agree that some form of "accountability" is necessary, a debate rages over the definitions, organizational structures, and the validity and reliability of measurements used to document accountability.

Some educators have voiced opposition to the analogy which appears to be inherent in "equating the educational process with the type of engineering process that applies to industrial production."[52] Educational engineering, as defined by Lessinger,[53] refers to an interdisciplinary field whose goal is the operation of the education enterprise in an efficient and effective manner. This goal would be accomplished through the use of instructional technology together with systems analysis, management by objectives, and contract engineering, e.g., logistics, quality assurance, value engineering, human factor engineering, etc. A major objective of educational engineering may well be to arm educational practitioners with both the technological competence associated with essential engineering generalizations and strategies and the tools and professional expertise of a successful instructor or educational manager.

By its very nature, accountability implies maximum productivity and efficiency (in an educational and an economic sense) in that the effectiveness of the educational dollar (input) is identified as a primary factor in attaining the maximum student achievement (output). Similar to Lessinger's notion of performance contracting, cost-effectiveness is a process through which accountability may be achieved. Lessinger[54] focused on "results obtained for resources used," while Deterline[55] viewed accountability in education as eventually being "implemented on an efficient, cost-effectiveness basis . . ."

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[52] Henry S. Dyer, "Toward Objective Criteria of Professional Accountability in the Schools of New York City," PHI DELTA KAPPAN, LXII (December, 1970), 211.

[53] Leon Lessinger, "Engineering Accountability for Results in Public Education," PHI DELTA KAPPAN, LXII (December, 1970), 217.

The literature contains several descriptions of programs and organizational structures which may be used to achieve accountability. Lessinger[56] offered the "educational engineering" program and structure, while Dyer[57] developed characteristics of an educational accounting system based on his "pupil-change model." This second model is based on the notion that a school is a social system which ffects changes of various kinds in both the children who attend the school and in the professional personnel responsible for maintaining it. The school as a social system becomes an educational system when its constituents--pupils, teachers, principal--are working toward some clearly defined pupil performance objectives. The model identifies four groups of variables--input, educational process, surrounding conditions, and output--which must be identified and measured if one is to develop acceptable criteria of staff accountability.

Introduction of the concept of accountability has generated many philosophical and methodological controversies. McComas'[58] statement that achievement of the learner should be the focal point of analysis and evaluation captured the essence of the literature on accountability. The major problem seems to be finding measurement tools that provide the necessary criteria of "consistency of findings, validity and replication."[59] Barro[60] encouraged the use of multiple regression analysis coupled with "result-oriented data and reason-oriented data," which would be examined to identify and assign a value to effectiveness indicators. Lopez,[61] however, felt that measurement technology does not yet meet even minimum standards of reliability and relevancy. In light of this controversy, Catallozzi[62] and Wildavsky[63] believed that only observable and measurable phenomena should be tested by using standardized tests and significant norms, respectively. This approach, however, requires the assumption that all human experience is open to such measurement.

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[54] Ibid., 217.

[55] William A. Deterline, "Applied Accountability," EDUCATIONAL TECHNOLOGY, XI (January, 1971), 20.

[56] Lessinger, PHI DELTA KAPPAN, 217.

[57] Dyer, PHI DELTA KAPPAN, 211.

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[58] J. D. McComas, "Accountability: How Do We Measure Up?" EDUCATIONAL TECHNOLOGY, XI (January, 1971), 31.

[59] Barro, PHI DELTA KAPPAN, 204-05.

[60] Barro, PHI DELTA KAPPAN, 201.

[61] Felix M. Lopez, "Accountability in Education," PHI DELTA KAPPAN, LXII (December, 1970), 231.

[62] John Catallozzi, "Accountability and Responsibility in Education," JOURNAL OF EDUCATION, 154 (December, 1971), 22.

[63] Aaron Wildavsky, "A Program of Accountability for Elementary Schools," PHI DELTA KAPPAN, LXII (December, 1970), 212.

Creating Alternatives

It is often asserted[64] that educational systems, particularly those characteristic of large cities, have failed to teach effectively or motivate significantly large numbers of disadvantaged youth. The first response has been to increase expenditure levels in the schools in order to compensate for disadvantages in student backgrounds, most notably through the Elementary and Secondary Education Act of 1965. The additional funds seem to have been expended in very traditional ways, e.g., reducing class size and/or procuring the assistance of remedial specialists, with unimpressive results. In 1971, the Rand Corporation[65] conducted a review and synthesis of research findings concerning the effectiveness of education for the President's Commission on School Finance. One implication of the report was that increased expenditures for traditional educational practices are not likely to improve educational outcomes substantially. Despite the abundance of new alternatives, curricula, and instructional technologies available for consideration, the implementation and evaluation of these possibilities have scarcely been considered.

Moynihan endorsed a national educational policy strategy which "launch[es] a serious and sustained effort to discover effective ways to achieve the goals the public has come to expect."[66]

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[64] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," JOURNAL OF HUMAN RESOURCES, 1 (1970), 24-33.

[65] Harvey A. Averch, et al., HOW EFFECTIVE IS SCHOOLING? A CRITICAL REVIEW AND SYNTHESIS OF RESEARCH FINDINGS, (Santa Monica, CA: Rand, 1972), pp. xii-xiii.

[66] Daniel P. Moynihan, "Equalizing Education: In Whose Benefit?" THE PUBLIC INTEREST, (Fall, 1972), 87.

Systems Approach in Education

"Systems analysis is the comparison of alternative means of carrying out some function, when these means are rather complicated and comprise a number of interrelated elements."[67] As early as 1959, Kershaw and McKean[68] in their work for the Rand Corporation proposed the use of systems analysis in education in order to assess the possibilities of making quantitative comparisons of educational systems. Before a system is analyzed, however, a picture of the particular system must be conceived. The systems approach uses system models and analyses and is

> . . . a rational approach for designing a system to attain specific objectives: a set of techniques for resolving problems through scientific method and the use of models and quantitative analysis techniques.[69]

The system model, according to Coombs,[70] functions

> . . . as a wide-angled lens trained on an organism so that it can be seen in its entirety, including the relationships among its (component) parts and between the organism and the environment.

The conceptual framework should possess a "degree of scientific explanation" and should, in the case of schools, "represent activities consciously organized for the express purpose of achieving certain prescribed educational and training objectives."

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[67] Joseph A. Kershaw and Roland N. McKean, SYSTEMS ANALYSIS AND EDUCATION,(Santa Monica, CA: Rand, 1959), p. 1.

[68] Ibid.

[69] Stephen J. Knezevich, PROGRAM BUDGETING (PPBS),(Berkeley, CA: McCutchan, 1973),p. 330.

[70] Philip H. Coombs, THE WORLD EDUCATIONAL CRISIS: A SYSTEMS ANALYSIS, (New York: Oxford University Press, 1968),p. 8.

> The framework contains a set of inputs, which are subject to a process, designed to attain certain outputs, which are intended to satisfy the system's objectives.[71]

A significant curricular innovation may entail substantive changes in instructional methods requiring changes in the deployment of time, in physical facilities and equipment, and in the number and kind of personnel required. These alterations have consequences for the system's input requirements as well as for the quantity and quality of its final outputs.

Systems analysis includes

> . . . a continuous cycle of activities based on defining objectives, designing alternatives to achieve objectives, evaluating alternatives on a systematic basis, using models of units under study, and using scientifically oriented decision procedures; a method of inquiry or way of looking at problems; a highly rational approach to analysis emphasizing the tools of economics; quantitative analysis approaches.[72]

As an economic concept, the aim is to find the best, i.e., most productive, use of resources and the word "systems" indicates the complex nature of the alternatives being compared and therefore the difficulty of the comparisons. Aided by such an analysis, an educational system is in a better position to choose its own response to meet external exigencies.

Kershaw and McKean[73] stressed the need for the development of the models and/or relationships required to estimate all costs, alternative processes, and output measures before the comparisons could be made. Their report contained a discussion of the difficulties involved in measuring output, a proposal for estimating incremental costs and output from new systems and a method for putting cost and output together to compare systems. A precondition for systems analysis is the generation of viable alternatives as available options, which then can be subjected to analysis to facilitate decision making.

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[71] Ibid., p. 9.

[72] Knezevich, PROGRAM BUDGETING, p. 330.

[73] Kershaw and McKean, SYSTEMS ANALYSIS, pp. 56-58.

Numerous applications of systems analysis techniques in education could be cited but Program Planning and Budgeting Systems (PPBS) have had the most publicity. PPBS may be described as an integrated system designed to provide governmental officials with greater and more accurate information for long range planning of programs and for making choices among optional ways of allocating funds to achieve governmental objectives. It aids the decision-making process by helping to identify new ways, through analysis and evaluation of public programs, of operating the government faster, more effectively, and efficiently. Conceptually, PPB is a "socially innovative system" since the analysis requires that activities be considered as they relate to each other--some complementary, some competitive. Optional ways of combining resources, such as, teachers, teacher aids, facilities, and teaching materials to effect the product desired are also considered.[74] PPB integrates the techniques of program development and budgeting. The following steps summarize the standard procedures of the PPBS process:

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[74] Selma Mushkin and James R. Cleaveland, PLANNING FOR EDUCATIONAL DEVELOPMENT IN A PLANNING, PROGRAMMING, BUDGETING SYSTEM, State-Local Finances Project, George Washington University, (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1968), p. 8.

(1) Clarifying and specifying the ultimate goals or objectives of each activity for which a government budgets money;

(2) Gathering contibuting activities into comprehensive categories of programs to achieve the specified objectives;

(3) Examining as a continuous process how well each activity or program has done--its effectiveness--as a first step toward improving or even eliminating them;

(4) Analyzing proposed improvements or new program proposals to see how effective they may be in achieving program goals;

(5) Projecting the entire cost of each proposal not only for the first year but for several subsequent years; and

(6) Formulating a plan, based in part on the analysis of program cost and effectiveness, that leads to implementation through the budget.[75]

Mushkin and Pollak discussed programming for educational development within the confines of an integrated PPB system. An essential aspect of the system is the analysis of the cost and effectiveness of a range of program alternatives. Modern science techniques are applied "to a process of reasoning about the costs and benefits of competing programs and program levels within a conceptual framework that is drawn largely from economic theory."[76] The plethora of techniques being used today suggest that there are no fixed rules with regard to program analysis. However, the following steps generally are used in conducting the program analysis aspect of PPB:

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[75] Ibid., p. 9.

[76] Selma J. Mushkin and William Pollak, "Analysis in a PPB Setting," Johns et al., eds., ECONOMIC FACTORS AFFECTING THE FINANCING OF EDUCATION, p. 329.

(1) Defining the problem or problems;

(2) Identifying the real or basic governmental objectives involved;

(3) Formulating criteria or measures of effectiveness that will capture as fully as possible each of the objectives as defined and will permit measurement of progress toward those objectives. (The criteria should not be limited to those that are quantifiable);

(4) Structuring the problem to make clear the relation of the outputs and inputs involved (or developing some even rudimentary notion of a model);

(5) Identifying and describing the key features of alternative ways of attempting to meet the problem. Alternatives may be used in the form of different programs or different levels of programs, or both;

(6) Estimating the full cost implications of each alternative to include future as well as immediate implication and to provide even an approximate set of figures on the marginal cost of various options. (Variable costs, both capital and operating, would be included, as well as both direct and indirect);

(7) Analyzing alternatives in terms of the effectiveness criteria set forth;

(8) Presenting in a clear way the tradeoffs among program options that reflect both costs and effectiveness;

(9) Identifying the major uncertainties and the quantification of those uncertainties to the extent possible;

(10) Identifying the major assumptions made in the study, with an indication of the degree to which program choices are sensitive to those assumptions; and

(11) Documenting in a detailed memorandum the study work that was done so that others can understand and evaluate the analysis. The documentation may point to a preferred alternative option.[77]

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[77] Ibid., pp. 330-31.

Mushkin and Pollak[78] grouped these rules into four phases: (1) definition of the problem, (2) application of imagination and creativity in searching for optional ways of meeting the defined objectives, (3) identification of the components of costs (both direct and indirect and both capital and operating), and (4) identification of the relative measures of effects or of benefits that are likely to follow from the program option.

Techniques for Analyzing Returns from Educational Systems

There is a new emphasis on planning in the educational literature commensurate with a need for greater precision in data collection and analysis. Formalization of the decision-making process appears to to be a product of data-based decision making. Techniques have been developed to aid in the decision-making process with respect to allocating resources to education and determining the mix of resources which is most effective. Three techniques presently are available: input-output, cost-effectiveness, and cost-benefit. Each implies a relationship between resources and products, but the techniques have not been refined to a point where they provide a definitive basis for decision making.[79] The concepts will be introduced at this point but both input-output and cost-effectiveness analyses are discussed in greater detail in ensuing chapters. Cost-benefit analysis is introduced to distinguish it from cost-effectiveness analysis. The two are often confused.

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[78] Ibid., pp. 331-32.

[79] Thomas, THE PRODUCTIVE SCHOOL, p. 80.

Input-Output Analysis

Input-output analysis is designed to examine the effect of changes in certain input variables on the outcome or output variable of the system under study. Inputs are the resources employed to achieve objectives; outputs (often expressed numerically) are the products of a program. This technique, however, generally disregards program or process components. Studies utilizing this approach assume that student educational outcomes are determined by the quantity of resources the school makes available to them; by the personal, family, and community characteristics that influence learning--typically grouped under the term "background factors"--and by the influence of peers. In this approach, the school routes resources to students but the structure and organization of the school and of its programs are ignored. Theoretical justification for input-output analysis rests on the educational or psychologist's production function approach to resource allocation mentioned earlier--the production function being a formal representation of the relationship between school and non-school resources and student outcomes. This relationship is commonly expressed in the form of a mathematical relation or multiple regression equation for statistical treatment. Representative studies utilize multivariate analysis of cross sectional data from a relatively large sample of schools. Data are collected on the resources to be examined and on the measure of output, usually achievement on a standardized norm-referenced instrument. The result is an equation which indicates the efficacy of each input variable in the presence of the other input variables.[80]

Decision procedures based on input-output studies should include the following steps:

(a) Calculate regression equations based on measures of inputs and outputs in a population of school systems similar to those within which the decisions are to be made;

(b) Study regression coefficients, and note the treatment effects which are subject to the control of policy makers;

(c) Examine the costs of alternative combinations of inputs and relate these costs to the predicted effect; and

(d) Implement the alternative which has the most favorable predicted input-output relationship, and observe the results of this implementation.[81]

Cost-Benefit Analysis

Cost-benefit analysis has attracted much interest as a technique of investment appraisal which in recent years has come to be applied to the public sector. This interest originated in the 1950's as a result of attempts to rationalize the large-scale development of major river valleys in the United States. The technique also has been applied to nationalized industries, health expenditures, housing schemes, traffic networks, land-use and town-planning problems, regional development, and education. "In one sense, it is an attempt to do explicitly what the price mechanism does implicitly, namely, to choose investment projects in order of their benefits per unit of cost."[82]

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[80] Averch, *et al.*, HOW EFFECTIVE IS SCHOOLING?, p. 31.

[81] Thomas, THE PRODUCTIVE SCHOOL, p. 80.

Cost-benefit analysis affords a means of choosing among alternative ways of allocating resources, either between education and other public activities or within the educational sector. Even within the educational sector, however, cost-benefit is a macro-analysis model which uses only gross categorizations of education. The objective of this model is to compare the difference between the present value of benefits and costs, i.e., the internal rate-of-return. The benefits and costs are expressed in terms of dollars.

The calculation in monetary terms of indirect social benefits and costs from externalities and spillovers also is attempted. In other words, the "calculation of the benefit-cost ratio, therefore, requires a kind of social accounting which is significantly different from that used by the businessman who is evaluating a proposed private sector investment."[83] The principal of "maximum social gain" is assessed, for it provides a framework which helps assure compliance with this principle by assisting the decision makers in designing the project for maximum efficiency, in selecting the optimum program size, and in choosing the most productive options available among various alternatives.[84] The procedure calls for the specification of goals or objectives and the development or endorsement of a program to accomplish the objectives, which should be of efficient design and optimum size. An attempt is made to mix acquirable resources (inputs) in such a manner as to maximize output for any cost through the use of linear programming.

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[82] Blaug, INTRODUCTION TO THE ECONOMICS, pp. 120-21.

[83] Robert H. Haveman, THE ECONOMICS OF THE PUBLIC SECTOR, (New York: Wiley, 1970), p. 151.

[84] Ibid., pp. 151-56.

Comparing alternatives requires a comparison of the internal rate-of-return or the analysis of the present value of the alternatives. Internal rate-of-return is the value stream of benefits minus the value stream of costs, as $V_o(B) - V_o(C)$,

$$\text{where } V_o(B) = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} \quad \text{and}$$

$$V_o(C) = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

Present value analysis is the important aspect in the benefit-cost ratio:

$$\text{B/C ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}} \quad [85]$$

When the above formulas are used, the decision rules should include the following, according to Thomas:[86]

> (a) If the rate-of-return to investment in education is greater than that in the remainder of the economy, society should increase its expenditures for education.

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[85] For explanation of formulas, see discussion of internal rate-of-return and present value analysis on p. 9.

[86] Thomas, THE PRODUCTIVE SCHOOL, p. 87.

(b) If the rate-of-return for one level of education (say, pre-school, or secondary) is greater than that for another, resources should be re-allocated within the educational enterprise in favor of those levels with the higher rate-of-return.

(c) Investments in job-related programs, such as vocational education or manpower training programs should be determined in part by the present value of streams of income and cost resulting from these programs.

(d) An individual should invest in an increment in education under the following conditions: (i) if the present value of the additional income to be obtained is greater than the present value of costs (for whatever discount rate the individual chooses); or (ii) if the internal rate-of-return associated with obtaining a given amount of education is greater than the rate-of-return obtained from other investments which are considered.

There are, of course, limitations to a procedure which uses income as the criterion variable. Nevertheless, a number of decisions, appropriately based on this kind of analysis, includes the following:

(a) Nations which are interested in increasing their rate of economic growth must include in their considerations the development of human capital. This involves carrying out a macroanalysis of the costs and benefits of education.

(b) State departments of education which are evaluating the results of their vocational education programs must be concerned with the ability of graduates of the programs to obtain gainful employment. It is, therefore, appropriate that states carry out cost-benefit analysis of their vocational educational programs.

(c) School boards as well as teachers may base decisions on a cost-benefit analysis of salary schedules. School boards' decisions in establishing the schedules will be affected by the effect they have on teachers' decisions to upgrade their qualifications. Teachers' decisions to enter the profession, to upgrade their qualifications, or to move from one school system to another are probably affected by their perceptions

> of the salary benefits they will receive as a result of their action, as well as by the concomitant costs.[87]

Cost-benefit analysis yields imprecise answers when applied to questions involving the selection of curricula, the division of time among subject areas, or the assignment of students on the basis of ability or other criteria to a given program of instruction, e.g., determining the costs and benefits of teaching world history in the ninth grade. Cost-benefit analysis would be appropriate, however, for decisions concerned with respect to broadly defined vocational and professional programs where, for example, future occupational success is an appropriate measure of output and the cost of training is an important input measure. Thus, the benefit measure is the increase in the level of aggregate output and the increase in the individual's ability to earn higher income.[88] The individual is likely to receive increased earnings throughout his lifetime which, of course, will lead to an increase in his income tax and other tax liabilities.[89] The former is a private benefit; the latter is considered a social benefit.

Cost-Effectiveness Analysis

> As it has been applied, cost-benefit analysis [is] a technique for evaluating public investment projects that compete actually or potentially with similar projects in the private sector: that is, the market mechanism generates a price for

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[87] Thomas, THE PRODUCTIVE SCHOOL, pp. 87-88.

[88] Michael E. Borus, John P. Brennan, and Sidney Rosen, "A Benefit Cost Analysis of the Neighborhood Youth Corps: The Out of School Program in Indiana," JOURNAL OF HUMAN RESOURCES, 5 (Spring, 1970), 139.

[89] W. Lee Hansen and Burton Weisbrod, BENEFITS, COSTS AND FINANCE OF PUBLIC HIGHER EDUCATION, (Chicago: Markham, 1969), p. 14.

> the activity in question which can be used to translate the benefits of the public project into terms directly comparable to its costs . . . But what if the (public) service in question is not produced at all and never has been by the private sector, so that there simply are no market-generated prices to start from? The appropriate evaluation technique in all such cases is not cost-benefit analysis, but cost-effectiveness analysis.[90]

As was apparent in the preceding discussion of cost-benefit analysis, the earnings of educated people may be used as 'prices' with which to evaluate the output of the educational system. Whether these prices correspond to the 'value added' by education is another question, which is properly dealt with by cost-effectiveness analysis because the goals of education are not extrinsic alone but intrinsic, e.g., personal enrichment or the cultivation of potential talents.

Broadly defined, cost-effectiveness analysis is, like the preceding two techniques, designed to assist a decision maker in identifying a preferred choice from among possible alternatives.[91] It is a means of relating the cost of a particular activity or project to effective performance or goal attainment.

Benson[92] and Fisher[93] identify six main attributes of cost-effectiveness analysis:

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[90] Blaug, INTRODUCTION TO THE ECONOMICS, p. 121.

[91] E. S. Quade, "Introduction and Overview," in COST-EFFECTIVENESS ANALYSIS: NEW APPROACHES IN DECISION-MAKING, T. A. Goldman, ed., (New York: Praeger, 1969), p. 1.

[92] Benson, ECONOMICS OF PUBLIC EDUCATION, p. 257.

[93] Gene H. Fisher, THE WORLD OF PROGRAM BUDGETING, (Santa Monica, CA: Rand, 1966), pp. 12-13.

(1) The essential characteristic is the systematic examination and comparison of alternative courses of action. The courses of action are those which might be taken to achieve specified objectives in some future time period.

(2) Not only does one consider those relevant alternatives that are revealed under initial search but one constantly seeks to design new alternatives.

(3) The systematic examination of alternatives, both old and new, frequently suggest some modification in the objectives themselves. This is to be encouraged.

(4) Critical appraisal of alternatives rests mainly on the assessment of costs, both direct and indirect and in the future as well as the present, and on the assessment of gains or benefits that accrue to each of the different courses of action.

(5) However, while most of the work is quantitative in nature, it should frequently be supplemented by qualitative analysis.

(6) Lastly, the time period of the analysis is an extended one. This creates problems in the treatment of uncertainty that should be dealt with explicitly.

According to Blaug, cost-effectiveness analysis clearly is a more broadly applicable evaluation technique than cost-benefit analysis, "since it is completely neutral with regard to the nature of the objectives themselves."[94] In principle, any objective that can be expressed in terms of a numerical index or scale will suffice. Amorphous objectives which cannot be scaled into meaningful units cannot, however, be used to evaluate educational projects or programs. Blaug said,

> This is not to assert that "what is not measurable is not significant" but rather that when decisions have to be taken in terms of more or less expenditure, the resort to certain

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[94] Blaug, INTRODUCTION TO THE ECONOMICS, p. 124.

> unspecified social, ethical, and spiritual contributions of education is simply designed to take questions of educational planning out of the realm of rational discourse.[95]

If the goal is purely an educational one, i.e., to maximize learning of a body of knowledge over a given time interval, then the "value added" over the time interval may be measured by the increment of gains in appropriate educational achievement as determined by pre- and posttesting. The goal also might be consumption oriented, e.g., to give students as much education as they can consume. If several objectives are involved in a given program or project, however, then they must be prioritized.

The technique combines costs and effectiveness by relating changes in skills obtained through a given set of educational variables (program) to a given cost. For example,[96] if the goal is for students to learn computer programming, several alternative procedures may be available, e.g., classroom instruction, classroom instruction supplemented by texts, and computer-assisted instruction. The cost of each instructional system and the students' capacity to write computer programs are measured in making an appropriate decision. The cost and effectiveness values of each program are combined in some manner into one cost-effectiveness value so as to compare the programs.

To place cost-effectiveness analysis in proper perspective, one first must locate it in relation to the systems analysis process.

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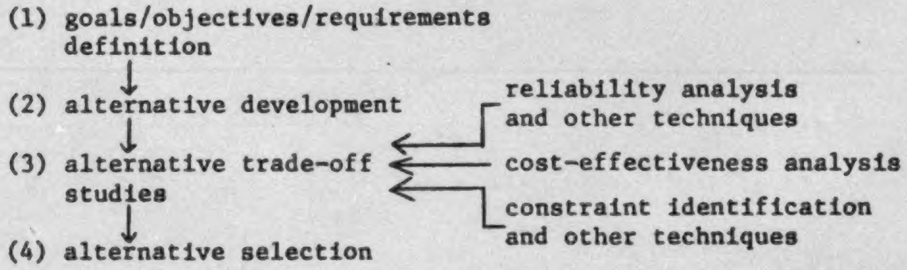
[95] Ibid.

[96] Thomas, THE PRODUCTIVE SCHOOL, p. 52.

> Cost-effectiveness is that aspect of systems analysis which emphasizes the systematic investigation of the decision maker's alternatives relative to objective criteria, costs, and effectiveness comparison, in addition to other trade-off factors associated with alternative selection.[97]

An analysis generally is referred to as cost-effectiveness analysis "if the emphasis is on finding significant differences in the cost or resource requirements among the available alternatives."[98] The systems analyst is forced to deal with the question of what ought to be done, i.e., problems of management or the suitability of the entire task. Some practitioners perceive cost-effectiveness analysis to be the systems analysis process itself; others see cost-effectiveness analysis as being related to and a subset of the total systems design process. Both interpretations of the role of cost-effectiveness analysis could be appropriate, depending upon the time and conditions that the analysis requires.

Heaton depicted the relationship of systems analysis to cost effectiveness as follows:[99]


(1) goals/objectives/requirements definition
(2) alternative development
(3) alternative trade-off studies
(4) alternative selection
reliability analysis and other techniques
cost-effectiveness analysis
constraint identification and other techniques

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[97] Quade, NEW APPROACHES IN DECISION-MAKING, p. 3.

[98] C. Bell, COST EFFECTIVENESS AS A MANAGEMENT TOOL (Springfield, VA: Clearinghouse for Federal Scientific and Technical Information, 1974), pp. 1-2.

[99] D. H. Heaton, "System/Cost Effectiveness Analysis in the System Engineering Process," DEFENSE INDUSTRY BULLETIN, 5 (1969), p. 35.

Summary

In this chapter, some basic economic and systems concepts, methodologies of analysis, and problems that have applicability in the development of a cost-effectiveness analysis model for education were reviewed.

The growing interest in the economic aspects of education generated interest in developing economic and systems tools of analysis, one of which is cost-effectiveness analysis. The central concept in economics is maximizing the benefits derived from scarce resources. To evaluate the efficiency with which a system uses its resources, one must conceptualize a model of the system, including its major interactive component parts, and gather information on the alternative uses of its component parts to achieve the goals of the system. The rational manner in which the information is gathered and presented becomes a part of the planning, evaluation, and decision-making process.

CHAPTER II

COST-EFFECTIVENESS IN EDUCATION

In this chapter the literature on cost-effectiveness is reviewed, and models are critiqued as they relate to the development of a cost-effectiveness/productivity analytical model. The development of such a model necessarily must build upon current knowledge about these techniques of evaluation which, as shown in Chapter I, are deeply rooted within the framework of systems and economic theory. The following discussion expands upon the introduction of cost-effectiveness analysis presented in Chapter I.

The discussion will focus on the purposes of cost-effectiveness analysis and models and studies using cost-effectiveness analysis. Various interpretations of the purpose of cost-effectiveness analysis exist in the literature. The interpretations and the definitions of cost-effectiveness analysis which follow from these interpretations, are based upon differing views of the relationship of cost-effectiveness analysis to the planning, systems analysis, and decision-making processes, the critical nature and boundaries of analysis, and potential applications in education.

In order to associate the state of model development to the problem addressed in this study, which is discussed in Chapter IV, the models will be categorized according to three factors:

(1) the purpose for which the models were developed
    or studies were undertaken;

(2) the interpretation given the role of cost-effectiveness in the planning and systems analysis processes; and

(3) the research design and/or procedures specified in the models or utilized in previous studies.

Purpose

In 1965, President Johnson announced his desire to introduce into other agencies of the executive branch an integrated Planning-Programming-Budgeting System (PPBS) similar to that employed in the Department of Defense. Cost-effectiveness analysis was seen as one dimension of a systems analysis approach to planning and decision making, such as PPBS.

Apparently Seiler wrote the first concise yet comprehensive textbook on cost-effectiveness theory and its non-military applications. Cost-effectiveness analysis was defined by Seiler as a

> . . .procedure by which the costs of alternative means of achieving a stated effectiveness, or, conversely, the effectiveness of alternative means for a given cost, are compared in a series of numerical indices. The objective of the analysis is to isolate the alternative or combination of alternatives that either gives the greatest expected effectiveness for a given expected cost or a given expected effectiveness for the least expected cost.[1]

He recognized the numerous potential applications of cost-effectiveness techniques by practitioners even though it is not an exact science. By this he meant that, although the margin of error in selecting from among alternatives can be reduced by analysis, it cannot be eliminated. Seiler likened cost-effectiveness analysis to classic economic theory when he stated:

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[1] Karl Seiler, III, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, (New York: Wiley-Interscience, 1969), p. 1.

> The similarity between the two is apparent when one considers a well-accepted definition of economics as being concerned with the allocation of scarce resources among competing ends to maximize satisfaction.[2]

Role of Cost-Effectiveness in Planning and Systems Analysis

Benson[3] espoused the use of cost-effectiveness analysis in education to help reduce or eliminate deficiencies in the allocation of public resources. He suggested the institutionalization of program budgeting as a means of attaining efficiency in education. Within the content of program budgeting the objectives of public programs would be defined in operational terms and alternatives which purport to accomplish these goals would be considered. Cost-effectiveness analysis aids in the choice of the most efficient alternative.

According to Hartley,

> . . .the need exists for a way of measuring the performance of policy makers and at the same time avoids as far as possible assumptions that cannot be empirically supported.[4]

He called for the wider usuage of system analysis techniques in order to "debug present designs" by adding:

> It is apparent in systems analysis that the best way to control the quality of output is to control the quality of input. However, public schools have no such intake

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[2] *Ibid.*, p. 2.

[3] Charles S. Benson, THE ECONOMICS OF PUBLIC EDUCATION, (Boston: Houghton Mifflin, 1968), p. 251.

[4] Harry H. Hartley, "Program Budgeting and Cost-Effectiveness in Local Schools," in BUDGETING, PROGRAMME ANALYSIS AND COST-EFFECTIVENESS IN EDUCATIONAL PLANNING, OECD-OCDE Education and Development Technical Report, (Washington, D. C.: Organization for Economic Cooperation and Development, 1968), p. 123.

valve; they must serve all.[5]

Pearson[6] related the confusion over the role cost-effectiveness plays in the systems analysis process to the fact that some practitioners perceive cost-effectiveness analysis to be synonymous with the systems analysis process itself, whereas others view the process of cost-effectiveness as being related to and a subset of the total systems design process.

Schwarz provided a distinction between program budgeting and cost-effectiveness analysis. Program budgeting, a concept in systems analysis, is a method used to distribute funds within the traditional line-item accounts of governmental departments among any number of specific programs. Since programs are activities that have unique objectives, a logical extension of program budgeting is performance budgeting. "Performance budgeting is simply cost-effectiveness analysis confined to the broad functional objectives of the programs that make up a departmental budget."[7]

Whereas Schwarz perceived program budgeting and cost-effectiveness as sequential functions, Fisher viewed cost-effectiveness as one of three components of program budgeting. There are three aspects of program budgeting, according to Fisher:[8]

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[5] _Ibid._, p. 125.

[6] Robert Hardy Pearson, "A Study of Cost-Effectiveness Analysis with Implication for Instructional Decision-Making," (unpublished Ph.D. dissertation, Syracuse University, 1972), pp. 27-31.

[7] Brita Schwarz, "Introduction to Programme Budgeting and Cost-Effectiveness Analysis in Educational Planning," in BUDGETING, PROGRAMME ANALYSIS AND COST-EFFECTIVENESS IN EDUCATIONAL PLANNING, p. 33.

> (1) The structural aspects of program budgeting are concerned with establishing a set of categories oriented primarily toward "end-product" or "end-objective" activities that are meaningful from a long-range-planning point of view.
>
> (2) Analytical process considerations pertain to various study activities conducted as an integral part of the program budgeting process. The primary objective of this type of analytical effort is to systematically examine alternative courses of action in terms of utility and cost, with a view to clarifying the relevant choices (and their implications) open to decision-makers in a certain problem area.
>
> (3) Information system considerations are aimed at the support of the first two items for progress reporting and control purposes and for providing data and information to serve as a basis for the analytical process.

Fisher used the term "cost-utility" to label the analytical process in program budgeting. However, he cautioned that numerous terms have been used to convey the same meaning--cost-effectiveness being one. For him the analysis could include the systematic examination of all relevant alternatives, the design of additional ones, and modification of the initially specified objectives. This is a more encompassing meaning than the one given by Quade, who pointed out that

> every systems analysis involves, at one stage, a comparison of alternative courses of action in terms of their costs and their effectiveness in attaining a specified objective.[9]

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[8] Gene J. Fisher, "The Role of Cost-Utility Analysis in Program Budgeting," in PLANNING PROGRAMMING BUDGETING, A SYSTEMS APPROACH TO MANAGEMENT, Fremont J. Lyden and Ernest G. Miller, eds., (Chicago: Markham, 1972), pp. 265-66.

[9] Quade, quoted in Schwarz, BUDGETING, PROGRAMME ANALYSIS, p. 33.

Hartley believed "cost-effectiveness analysis should be conducted only after a program structure had been devised and criteria to assess performance had been specified."[10] Others, as reviewed by Pearson,[11] have envisioned cost-effectiveness as broader in scope, whereby performance criteria are developed and the decision as to which program alternatives are chosen for analysis is included.

The character of cost-effectiveness has changed in recent years, according to Schwarz, and it is now viewed as a method for

> . . .finding the most efficient use of an existing system toward [resolving] long range planning problems. The projection of cost-effectiveness into the future, however, entails the consideration of uncertain factors and less available data.

Therefore, a preferred alternative, rather than the optimal solution, is selected. The decision is a guarded one.[12] Rapp[13] also observed this change in the character of evaluation

> . . .from the concept of the traditional short-term highly structural experiment wherein all the variables are tightly controlled, to a concept of long-term, developmental evaluation in an atmosphere where variables are not controlled, but rather accounted for.

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[10] Hartley, BUDGETING, PROGRAMME ANALYSIS, p. 123.

[11] Pearson, "Study of Cost-Effectiveness," pp. 33-40.

[12] Schwarz, BUDGETING, PROGRAMME ANALYSIS, p. 33.

[13] M. L. Rapp, "Evaluating Innovative Educational Programs," in PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, Sue A. Haggart, et al., eds., (Santa Monica, CA: Rand, 1969), p. 160.

This change was seen as forced by the developmental aspects of numerous innovative programs. In this modern application, English[14] would simply predict the cost and effectiveness of an alternative and evaluate an alternative's worth on that basis rather than gathering the cost and effectiveness data after the fact.

Cost-Effectiveness in Decision Making

The uncertainties of the future may have prompted Fisher and Quade[15] to conclude that intuition and judgment will form the basis for making long range planning decisions. In this context, cost-effectiveness analysis will "sharpen this intuition and judgment."[16] These thoughts are consistent with those of Heymont and Jarrett. Cost-effectiveness analysis, according to Heymont,[17] is not a substitute for judgment, experience and common sense, but rather a method for systematic examination of all the subjective and objective data available, or according to Jarrett,[18] an analytical foundation for making sound objective choices among the various ways a problem might be solved or an objective met.

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[14] J. M. English, ed., COST-EFFECTIVENESS: THE ECONOMIC EVALUATION OF ENGINEERED SYSTEMS, (New York: Wiley, 1968), p. 7.

[15] Schwarz, BUDGETING, PROGRAMME ANALYSIS, p. 33.

[16] *Ibid.*, p. 33.

[17] Heymont, *et al.*, GUIDE FOR REVIEWERS OF STUDIES CONTAINING COST-EFFECTIVENESS ANALYSIS, AD 618892, (Springfield, VA: Clearinghouse for Federal Scientific and Technical Information, 1965), p. 1.

[18] H. F. Jarrett, COST-EFFECTIVENESS ANALYSIS FOR THE FIRE SERVICE: AN OVERVIEW, A Professional Paper (SP-2938), (Santa Monica, CA: Systems Development Corporation, 1967), pp. 7, 9.

Carpenter and Haggart[19] asserted that the information provided by the analysis is only one component of the decision-making process. The information is considered along with the planner's judgment and environmental constraints such as budget level or political atmosphere. The decision is not based totally on the alternative which maximizes or minimizes specific characteristics.

Critical Nature and Boundaries of the Cost-Effectiveness Analysis Process

Analysis is central to a broad comprehensive planning effort. The evaluation and analysis of educational programs, however, may be undertaken to advantage whether or not such analysis is part of an integrated planning, programming, and budgeting system. Mushkin and Cleaveland defined analysis as a

> process of systematically asking relevant questions about full cost implications and benefits of program alternatives to satisfy objectives and assembling information that bears on those questions.[20]

Analysis for them includes estimating costs and gains in meeting those purposes by alternative programs, inquiring about the uncertainty of those estimates, and documenting the information that is brought together to give greater precision to gains and costs for meeting stated objectives--by quantified description where possible and by qualitative statements where quantification is not possible.[21] Quade[22] has set forth some principles of good analysis which illustrate its critical nature:

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[19] Margaret B. Carpenter and Sue A. Haggart, "Cost-Effectiveness Analysis for Educational Planning," EDUCATIONAL TECHNOLOGY, X (October, 1970), 26.

[20] Selma Mushkin and James R. Cleaveland, PLANNING FOR EDUCATIONAL DEVELOPMENT IN A PLANNING, PROGRAMMING, BUDGETING SYSTEM, State-Local Finances Project, George Washington University, (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1968), p. 25.

> (1) The right problem must be tackled, i.e., discovering the appropriate objectives, searching out good criteria for choice, and choosing the best set of alternatives to compare.
>
> (2) The analysis must be systems oriented, i.e., finding the interdependencies that exist in a system's parts and studying the entire complex system even if it requires intuitive judgment.
>
> (3) Uncertainties should be recognized and an attempt should be made to take them into account by evaluating their impact on the answers. Answers change in response to changes in assumptions and estimates.
>
> (4) The analysis should attempt to discover new alternatives as well as to improve the obvious ones.
>
> (5) The analysis should strive to attain the standards traditional to science even though in problems of public policy the scientific method of controlled repeated experiment cannot be used. These are (a) intersubjectivity: results obtained by processes that can be duplicated by others to attain the same results; (b) explicitness: use of calculations, assumptions, data, and judgments that are subject to checking, criticism, and disagreement; and (c) objectivity: conclusions do not depend on personalities, reputations, or vested interest; where possible these conclusions should be in quantitative and experimental terms.

Quade's principles of good analysis give the role of analysis a broad interpretation. In statement (1) above, rather than simply specifying the objectives and the alternatives that have been chosen for analysis,

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[21] *Ibid.*, pp. 25-26.

[22] E.S. Quade, "Systems Analysis Techniques for Planning Programming-Budgeting," in PLANNING PROGRAMMING BUDGETING, A SYSTEMS APPROACH TO MANAGEMENT, pp. 252-253.

Quade assumed that objectives and criteria for choice have not been discovered. Statement (4) of his analysis includes a search for new alternatives and the improvement of the alternatives being analyzed. Statement (4) would not be included in a narrow interpretation of analysis, although data obtained during the analysis may generate new ideas and future changes.

Potential Applications of Cost-Effectiveness in Education

Carpenter and Haggart viewed cost-effectiveness analysis from the perspective of educational planning where "educational planning is ultimately concerned with achieving a more effective use of educational resources in improving pupil performance." Consequently, they stated "cost-effectiveness analysis is a tool that can assist the planner in relating the resources required by an educational program to its effectiveness, often measured by pupil achievement." They would restrict the term educational program to "a set of activities and resources that, taken together, bring about a specific kind of student learning." For planning purposes and analysis a program is "described in terms of certain basic characteristics--its effectiveness, its cost, its resource requirements, and the way it is carried out."[23] Thus, cost-effectiveness analysis may be used:

(1) to help assess the relative worth of several innovative programs with the same educational outcome (such as improvement in reading achievement);

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[23] Carpenter and Haggart, EDUCATIONAL TECHNOLOGY, 26.

(2) to determine whether a single program is becoming more or less effective as time passes so that steps may be taken to improve it, if necessary; or

(3) to help assess the relative worth of the same program for different student populations (such as those with different socioeconomic backgrounds) or in different school settings.[24]

Pearson[25] provided examples of three categories of cost-effectiveness analysis which, he cautions, are not clearly distinct: (1) system/component configuration study, (2) system comparison study, and (3) suprasystem comparison study. The system/component configuration study examines different components within a single system, for example, a closed-circuit instructional television system versus an open-circuit system. The system comparison study examines two or more systems established to achieve the same objective. It is presumed that each competing system has been selected as the preferred configuration after an intrasystem analysis, i.e., system/configuration component study. For example, the merits of a programmed instructional system might be compared to an autotutorial system after each has been instructionally validated. Pearson's third category is essentially a cost-benefit analysis where the merits of alternatives of widely differing capabilities and cost elements are compared. Here one could analyze the cost-effectiveness of competing instructional systems, for example, institutional study versus on-the-job training.

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[24] Ibid., 26.

[25] Pearson, "A Study of Cost-Effectiveness," pp. 27-32.

Haggart mentioned various approaches for comparing alternatives through cost-effectiveness analysis. She finds it useful to hold constant either cost (budget level) or effectiveness (achievement) arguing that "maximizing the cost-effectiveness ratio for the sake of the ratio alone can lead to some ridiculous extremes--like zero to infinite cost or zero to infinite effectiveness."[26] She would specify a performance criterion and examine the cost of achieving that effectiveness level for each alternative. Alternatives can be compared on the basis of the effectiveness level each attains for a single budget level. A second approach allows the examination of higher level problems with less well-defined objectives. When the scale of activity is fixed and the alternatives are not interdependent the cost-effectiveness ratio alone can be used to rank alternatives.[27] Setting arbitrary cost or effectiveness levels, however, would limit the full development of innovative programs, although, as a practical matter, boundary conditions on cost may be necessary. Rather, the analysis should involve clarifying and striking a balance between cost and effectiveness.

Curtis[28] preferred to use a cost-effectiveness tool to identify the relative successfulness of project components rather than to identify successful or unsuccessful projects. This necessitated a costing out of project components or processes. Curtis reasoned that if a decision maker has identified the need to reach an objective as a high priority, has determined a level of performance or an expectation for quality, and has initiated a process (e.g., a special reading program) which failed to resolve that need, "the decision maker must avoid eliminating the project in such a way as to eliminate the objective and thus ignore the need."[29] He made comparisons between processes which were common to more than one project as opposed to the comparison of two projects.

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[26] Sue A. Haggart, "Evaluating Alternatives in School District Planning," in PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, Sue A. Haggart, et al., eds., (Santa Monica, CA: Rand, 1969), p. 157.

[27] Ibid., pp. 157-58.

[28] William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corporation, Association of School Business Officials, 1971), pp. 241-42.

Alkin has identified potential applications of cost-effectiveness analysis:

> (1) Evaluating the cost-effectiveness of alternative programs where alternative programs are defined as differences in financial inputs to the system, without regard for the manner in which these inputs are utilized;
>
> (2) Studying specific total institutional programs of schools on the basis of their performance on the outcome dimensions after we have accounted for the effects of specific uncontrollable characteristics of their own system; and
>
> (3) Evaluating the cost-effectiveness of input utilization options. This considers the cost-effectiveness of specific costly manipulatable characteristics of the system and implies a concern for the maximization of outputs which utilizes the options for resource allocation within the system, the total financial input and student inputs, including time.[30]

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[29] Ibid., p. 241.

[30] Marvin C. Alkin, "Evaluating the Cost-Effectiveness of Instructional Programs," (from the proceedings of the Symposium on Problems in the Evaluation of Instruction, Center for the Study of Evaluation, University of California, Los Angeles, December, 1967), pp. 20-30.

Abt[31] would use a cost-effectiveness technique in urban school districts as a way to facilitate the introduction of the market mechanism into public school systems. He asserted that public schools possess both a political and economic monopoly over consumers, for most consumers cannot afford to place their children in private schools. The numerous hierarchical administrative layers which exist in urban school systems insulate school officials from the consumer demands for reform. The examination by parents of the cost-effectiveness of competing educational alternatives conducted by independent audits and the use of voucher payments by parents would establish the market mechanism in education and make educators more accountable, according to Abt.

Models and Studies

It is useful to group and label the available models and studies in a manner which points out the appropriateness or inappropriateness of the models and the procedures used in the studies to the problem addressed in Chapter IV.

Cost-Effectiveness Mathematical Decision Approach Models

Seiler suggested several preliminary considerations before utilizing cost-effectiveness. All alternatives should be assessed to determine which ones fall within feasible expected cost and effectiveness values. The remaining alternatives should be homogeneous with respect to or adjusted for differences in the projected time to obtain objectives, geographical location, skill levels of personnel operating the alternatives, and scale. Scale considers, as part of the expected merit of the alternatives or cost-effectiveness ratio, the net gain in savings or returns due to the avoidance of other costs. Seiler explains five types of mathematical approaches to reaching decisions:

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[31] Clark C. Abt, "Reforming Urban Education with Cost-Effectiveness Analysis," EDUCATIONAL TECHNOLOGY, X (September, 1970), 36-37.

> (1) Ratio. This measures the "efficiency" of a system in terms of the ratio of its output (effectiveness) to its input (cost), which results in the over-all figure of merit as a quotient.
>
> (2) Indifference Curve. This is a more complex device than the ratio model. First, an indifference curve model for analyzing the effectiveness of various combinations of two systems is described. This is followed by a description of means to handle three and greater than three combinations of systems. The decision makers could choose either all units of a system or any combination thereof with units of other systems (mixes of alternatives) if the cost would be the same and the figure of merit would be unchanged.
>
> (3) Mathematical Programming. Mathematical programming includes linear, nonlinear, integer, and dynamic programming, the calculus of variations, and optimal control theory. Assuming that all the variations within a system's variables are linear, typical linear programming problems today range from determining the optimum allocation of a system's productive resources among the competing products of those resources to determining minimum cost networks.
>
> (4) Game. The theory of games attempts to identify optimal strategies in conflict confrontation, i.e., there are different payoffs (effectiveness levels) to each player over the range of available strategies (alternatives), the costs of which are assumed to be equal.
>
> (5) Probabilistic Cost-Effectiveness. Since in the limits neither cost nor effectiveness is determinable when dealing with expected values of costs and effectiveness, cost and effectiveness are described only by their respective probability distributions. This enables the decision maker to weigh his confidence in the various alternative systems.

He identified various exogenous factors--technological advances, resources availability, political sensitivity and psychological stimulus--which may affect a decision after mathematical computations are completed.[32]

A Cost Effectiveness Model Synonymous with a Conceptual Framework of Education as a System

Abt[33] and his associates developed a cost-effectiveness model to evaluate the relative school, student, and community effects and associated costs of alternative programs for the disadvantaged funded under Title I of the Elementary and Secondary Education Act of 1965. The model focuses on the changes in student achievement, the attitudes and environmental factors influencing achievement, and the social behaviors and community impacts of improved achievement in the target population. The model emphasizes those aspects of the educational process that seem most relevant to achievement increases in students affected by Title I programs and for which quantitative data are widely available. Abt attempted to balance the demands for compact data input, limited model complexity, and validity of output. The model emphasized the quality and quantity of the output, not the process by which the output is produced. There are four main components of the model and each component has associated with it from one to four subcomponents. Figure 2.1 provides an overview of the model showing inputs, submodels, and outputs. The subcomponents are described as follows:

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[32] Seiler, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, pp. 71-101.

[33] Clark C. Abt, DESIGN FOR AN EDUCATION SYSTEM COST-EFFECTIVENESS MODEL, (Cambridge, MA: Abt Associates, 1967), pp. 2-6.

(1) Cost/Input accounts for costs required to implement Title I programs.

(2) Instructional Process represents the improvements in specific student achievement and attitude resulting from a Title I program.

(3) School Flow represents the production process whereby the inputs of four partially educated student types (white and non-white, above and below $2,000 family income) and education resources (teachers, equipment, facilities, community environment) are transformed into better educated individuals.

(4) Dropout/Truancy Calculation determines the dropout and truancy rates for the years during and after the Title I program.

(5) Course of Study represents the choosing of a course of study by students at some point in their school career.

(6) Community Interactions estimates the impact on two community variables of the changes in education system output due to Title I programs.

(7) Effectiveness/Output is the submodel in which the analysis and the output of the results determined by the other submodels takes place.[34]

Abt's model does not illustrate the analytical process of cost-effectiveness; rather, it provides a view of a system for the evaluation of the Title I programs.

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[34] *Ibid.*, pp. 5-6.

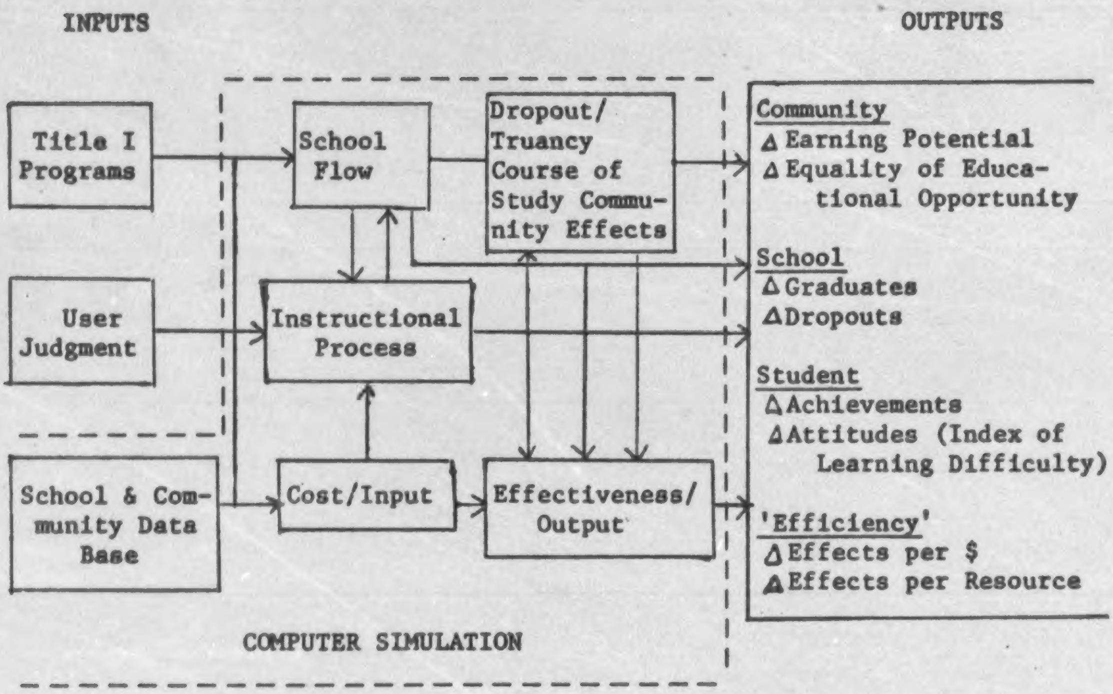
INPUTS
OUTPUTS
Title I Programs
User Judgment
School & Community Data Base
School Flow
Instructional Process
Cost/Input
Dropout/ Truancy Course of Study Community Effects
Effectiveness/ Output
Community
Δ Earning Potential
Δ Equality of Educational Opportunity
School
Δ Graduates
Δ Dropouts
Student
Δ Achievements
Δ Attitudes (Index of Learning Difficulty)
'Efficiency'
Δ Effects per $
Δ Effects per Resource
COMPUTER SIMULATION

Figure 2.1—Abt's Cost-Effectiveness Overview Model for ESEA Title I Programs

Source: Clark C. Abt, DESIGN FOR AN EDUCATION SYSTEM COST-EFFECTIVENESS MODEL, (Cambridge, MA: Abt Associates, 1967), p. 4.

Cost-Effectiveness Analysis as a Component of a Systems Approach to Planning, Programming and Budgeting

Cost-effectiveness analysis may be viewed either broadly or narrowly, that is, as part of or synonymous with a planning, program and budgeting system. Carpenter and Haggart[35] have developed an analytical model for school district planning (see Figure 2.2). Their model sketches the planning process by illustrating the components of program budgeting and analytical activities within program budgeting. The model stressed the interdependence between the components and the order of analysis. In their model cost-effectiveness analysis of alternatives is a component of program budgeting. However, the model is not descriptive of the steps one must take to conduct an analysis.

A financial planning model for education was developed by Sujjapunroj. He created an analytical model to evaluate current operations and to analyze the future consequences of alternative courses of action. The model (see Figure 2.3) consists of the following components:[36]

(1) Educational goals are identified and refined to guide all activities in the school district.

(2) Defined goals are translated into organizational programs, which are sets of activities designed to achieve school district's goals. Cost-utility analysis is used to select the best programs.

(3) In selecting the desired method for each program, the procedure of cost-effectiveness analysis is developed and presented.

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[35] S. A. Haggart and M. B. Carpenter, "Program Budgeting as an Analytical Tool for School District Planning," (Santa Monica, CA: Rand, no date), pp. 1-6.

[36] Naronk Sujjapunroj, "Financial Planning Model in Education," (unpublished Ph.D. dissertation, University of Minnesota, 1972).

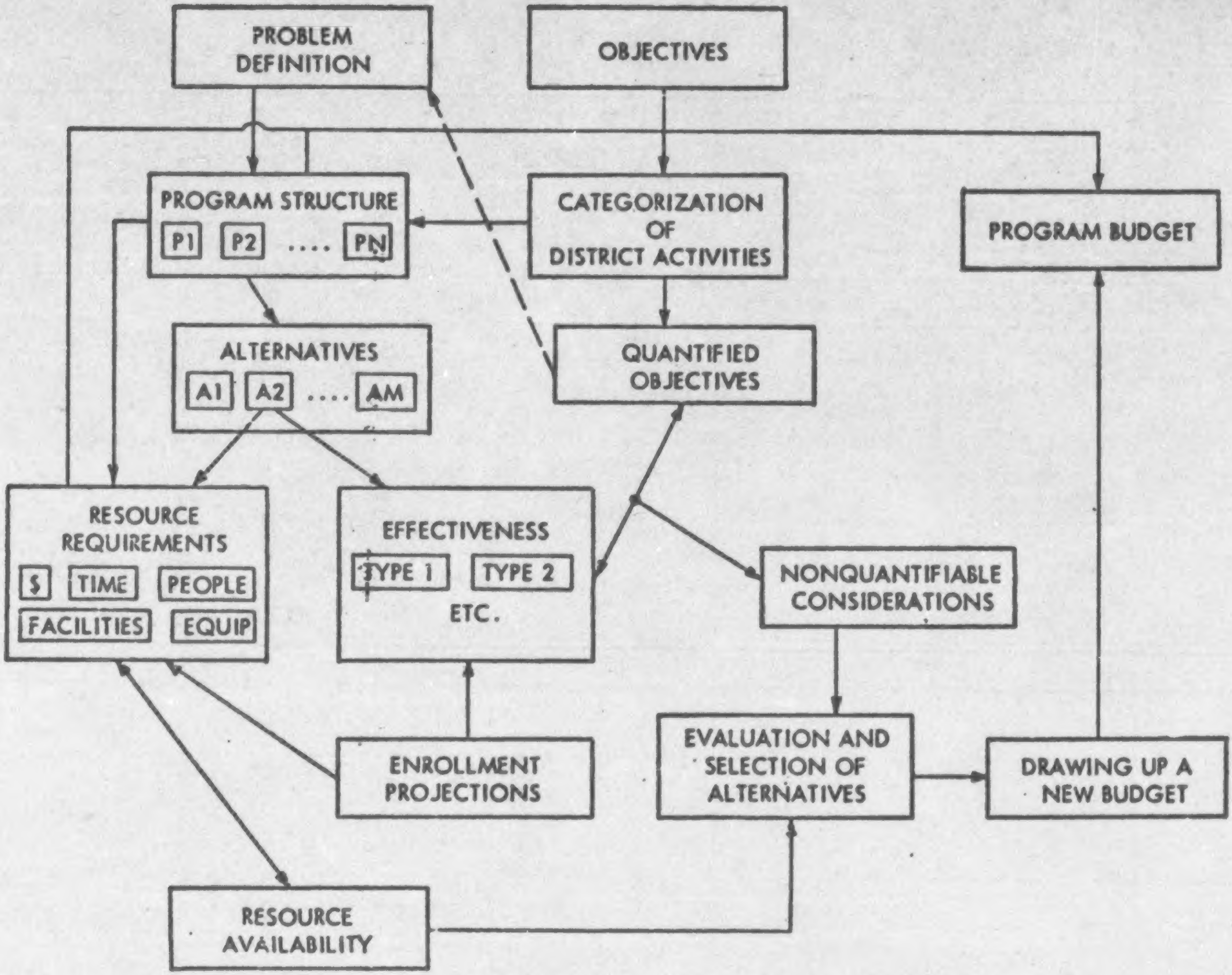
PROBLEM DEFINITION
OBJECTIVES
PROGRAM STRUCTURE
P1
P2
....
PN
CATEGORIZATION OF DISTRICT ACTIVITIES
PROGRAM BUDGET
ALTERNATIVES
A1
A2
....
AM
QUANTIFIED OBJECTIVES
RESOURCE REQUIREMENTS
$
TIME
PEOPLE
FACILITIES
EQUIP
EFFECTIVENESS
TYPE 1
TYPE 2
ETC.
NONQUANTIFIABLE CONSIDERATIONS
ENROLLMENT PROJECTIONS
EVALUATION AND SELECTION OF ALTERNATIVES
DRAWING UP A NEW BUDGET
RESOURCE AVAILABILITY

Figure 2.2—Carpenter and Haggart's Analytical Model for School District Planning

Source: S. A. Haggart and M. B. Carpenter, "Program Budgeting As An Analytical Tool for School District Planning," (Santa Monica, CA: Rand, no date), p. 2.

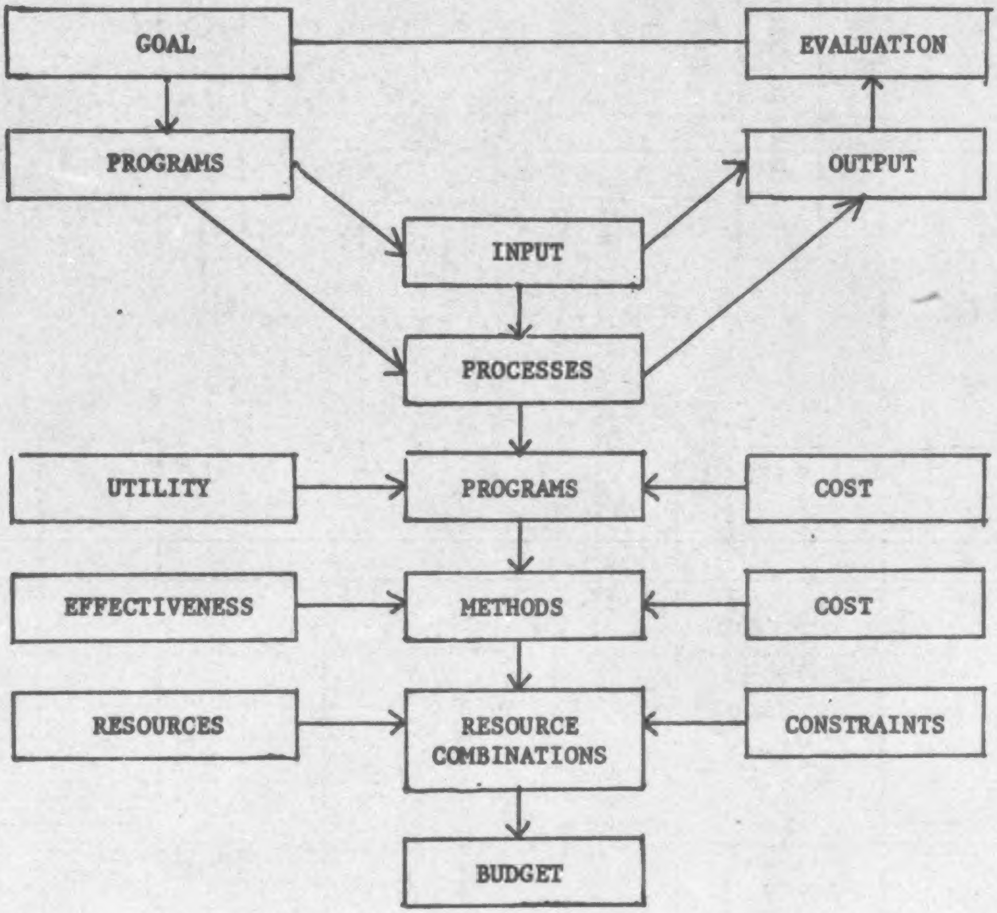
GOAL
EVALUATION
PROGRAMS
OUTPUT
INPUT
PROCESSES
UTILITY
PROGRAMS
COST
EFFECTIVENESS
METHODS
COST
RESOURCES
RESOURCE COMBINATIONS
CONSTRAINTS
BUDGET

Figure 2.3--Sujjapunroj's Structure of a Financial Planning Model

Source: Naronk Sujjapunroj, "Financial Planning Model in Education," (unpublished Ph.D. dissertation, University of Minnesota, 1972), p. 6.

(4) Linear programming analysis is used to determine the best combination of inputs within the methods.

(5) In order to monitor and control expenditures for the programs and methods, a program budget format is developed.

(6) Evaluation is used to determine how well the school district is performing as measured against the goals that have been set forth.

The model, like the previous one, simply shows the placement of cost-effectiveness (Step 3) in the planning process. Quade viewed the process of analysis as taking place in three sequential but overlapping stages. In the formulation stage, the issues are clarified, the extent of inquiry limited, and the elements identified. In the second or search stage, information is gathered and alternatives are generated. The structure of analysis represents the third stage.

> To start the process of evaluation or comparison, the various alternatives (which may have to be discovered or invented as part of the analysis) are examined by means of the models. The models tell us what consequences or outcomes can be expected to follow from each alternative; that is, what the costs are and the extent to which each objective is attained. A criterion can then be used to weigh the costs against performance, and thus the alternatives can be arranged in the order of preference.[37]

The key to successful analysis, according to Quade, is following a continuous cycle of formulating the problem, selecting objectives, designing alternatives, collecting data, building models, weighing cost against performance, testing for sensitivity, questioning assumptions and data, re-examining the objectives, opening new alternatives, building better models, and so on, until satisfaction is obtained or time or money force a cut-off.[38]

---

[37] Quade, PLANNING, PROGRAMMING, BUDGETING, pp. 249-50.

His model illustrates that cost and effectiveness values are estimated by utilizing cost-effectiveness models (see Figure 2.4). The components and the dynamic interaction of components from which to obtain cost and effectiveness values, however, are not illustrated.

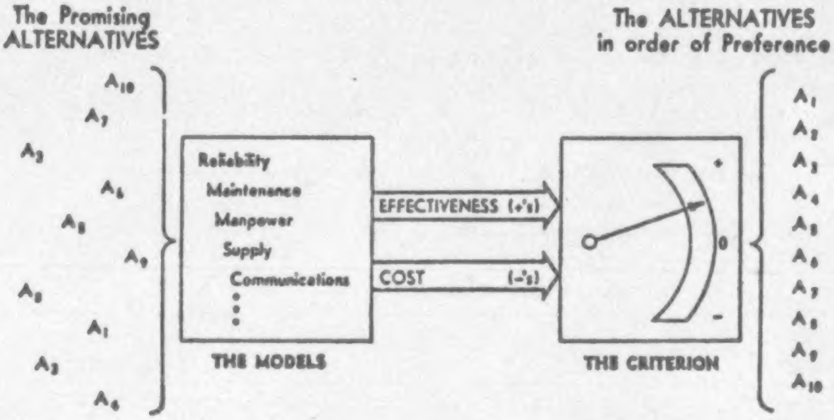
The Promising ALTERNATIVES
A_{10}
A_7
A_3
A_6
A_5
A_9
A_8
A_1
A_2
A_4
Reliability
Maintenance
Manpower
Supply
Communications
THE MODELS
EFFECTIVENESS (+'s)
COST (-'s)
+
0
-
THE CRITERION
The ALTERNATIVES in order of Preference
A_1
A_2
A_3
A_4
A_5
A_6
A_7
A_8
A_9
A_{10}

Figure 2.4--Quade's Structure of Systems Analysis in Planning - Programming - Budgeting

Source: E. S. Quade, "Systems Analysis Techniques for Planning-Programming-Budgeting," in PLANNING, PROGRAMMING AND BUDGETING, A SYSTEMS APPROACH TO MANAGEMENT, Fremont J. Lyden and Ernest G. Miller, eds. (Chicago: Markham, 1972), p. 250.

A Simplistic Flexible Model to Illustrate Cost-Effectiveness Applications

Alkin[39] proposed a simplistic model (see Figure 2.5) of cost-effectiveness to demonstrate its several applications in three types of evaluations. By labelling each and every variable as part of a control, predictor, or criterion set, the evaluator may 1) compare the cost-effectiveness of alternative instructional programs established to achieve the same or similar objectives where school financial resources represent instructional programs, 2) determine the cost-effectiveness of a particular school, where the cost-effectiveness scores for a school are based on the ratio of actual to predicted achievement on each of the criterion dimensions, or 3) compare the cost-effectiveness of various input utilization options. The assignment of each variable to a set depends on the type of evaluation being performed:

---

[38] Ibid., pp. 248-52.

[39] Alkin, PROCEEDINGS OF THE SYMPOSIUM ON PROBLEMS IN THE EVALUATION OF INSTRUCTION, pp. 7-30.

(1) Evaluating the Cost-Effectiveness of Alternative Instructional Programs--School Financial Resources

control variable sets: A and B
predictor variable set: C
criterion variable set: E

(2) Evaluating the Cost-Effectiveness of Total Institutional Programs

predictor variable sets: A, B, and C
criterion variable set: E

(3) Evaluating Cost-Effectiveness of Input Utilization Options

control variable sets: A, B, and C
predictor variables: $D_1, D_2, D_3 \ldots D_i$
criterion variable set: E

The components of Alkin's model include student inputs, financial inputs, manipulatable characteristics, outcomes, and external systems. Student inputs refer to the nature and characteristics of the students entering the program to be evaluated. Educational outputs refer to the cognitive and non-cognitive changes which take place in students after they are exposed to the instructional program and the impact of the program upon systems external to it. Financial inputs are resources made available for carrying on the program. Manipulative characteristics describe the ways in which the financial inputs are utilized within the program in combination with the student inputs. External systems are represented by formal and informal social, political, legal, economic, and other systems outside the school which encompass the program, impact upon it, and are in turn modified by the outputs.

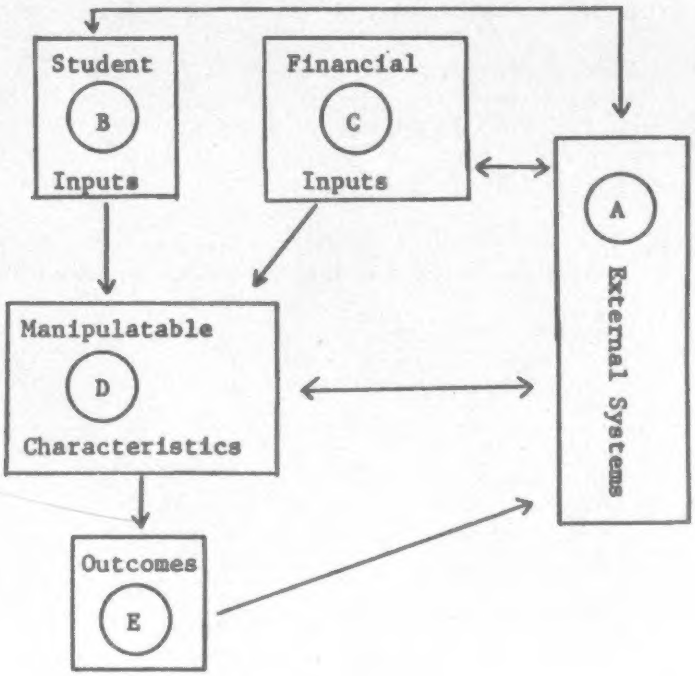
Student
B
Inputs
Financial
C
Inputs
A
External Systems
Manipulatable
D
Characteristics
Outcomes
E

Figure 2.5--Alkin's Cost-Effectiveness Model

Source: Marvin C. Alkin, "Evaluating the Cost-Effectiveness of Instructional Programs," PROCEEDINGS OF THE SYMPOSIUM ON PROBLEMS IN THE EVALUATION OF INSTRUCTION (UCLA: Center for the Study of Evaluation, 1967), p. 11.

A Cost-Effectiveness Model Emphasizing the Cost Dimension of Analysis

Blaschke and others[40] described a cost-effectiveness model (see Figure 2.6); called the COST-ED model, which was designed primarily for analyzing the projected economic characteristics of new instructional systems. Through its use performance contractors would be held accountable. The model related over 50 isolated cost factors to each other so that the impact of each on the ultimate cost per unit of student achievement could easily be identified.

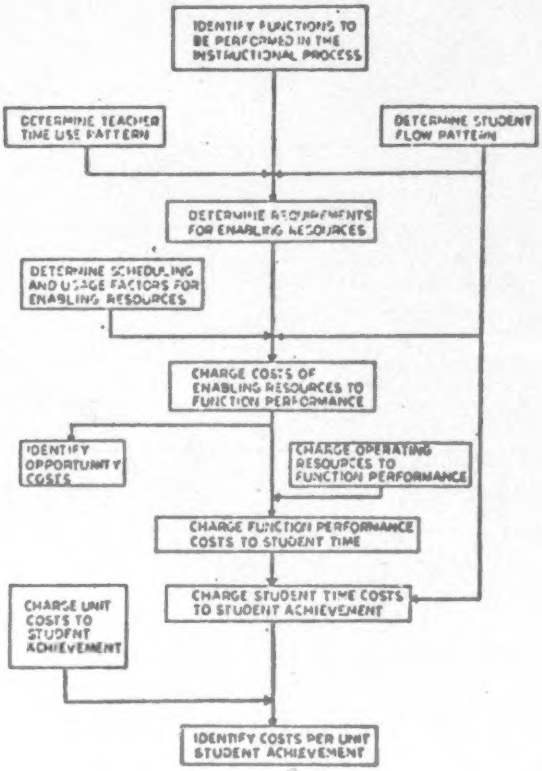
IDENTIFY FUNCTIONS TO BE PERFORMED IN THE INSTRUCTIONAL PROCESS
DETERMINE TEACHER TIME USE PATTERN
DETERMINE STUDENT FLOW PATTERN
DETERMINE REQUIREMENTS FOR ENABLING RESOURCES
DETERMINE SCHEDULING AND USAGE FACTORS FOR ENABLING RESOURCES
CHARGE COSTS OF ENABLING RESOURCES TO FUNCTION PERFORMANCE
IDENTIFY OPPORTUNITY COSTS
CHARGE OPERATING RESOURCES TO FUNCTION PERFORMANCE
CHARGE FUNCTION PERFORMANCE COSTS TO STUDENT TIME
CHARGE UNIT COSTS TO STUDENT ACHIEVEMENT
CHARGE STUDENT TIME COSTS TO STUDENT ACHIEVEMENT
IDENTIFY COSTS PER UNIT STUDENT ACHIEVEMENT

Figure 2.6--Blaschke's COST-ED Model

Source: Charles Blaschke, et al., "Performance Contract-Turnkey Approach to Urban School System Reform," EDUCATIONAL TECHNOLOGY, X (September, 1970), 47.

Figure 2.7 shows the basic modules which comprise the COST-ED model, each of which may or may not be used in a particular application depending upon the organizational environment, the objectives of the analysis, and the level of detail desired. The model does not however, make it possible to isolate and relate effectiveness to cost factors.

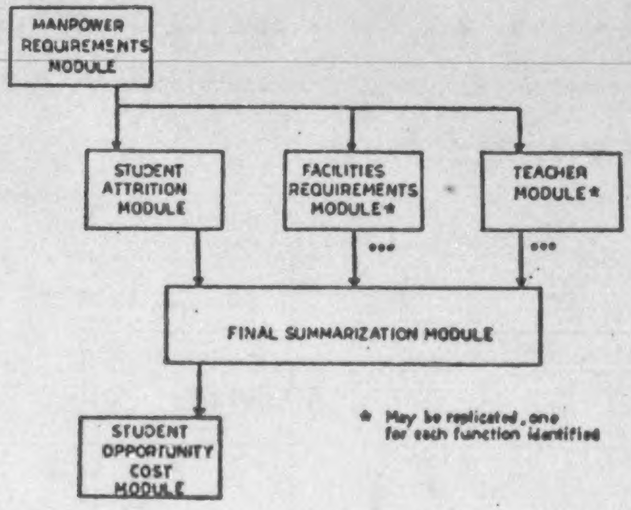
MANPOWER REQUIREMENTS MODULE
STUDENT ATTRITION MODULE
FACILITIES REQUIREMENTS MODULE*
TEACHER MODULE*
•••
•••
FINAL SUMMARIZATION MODULE
STUDENT OPPORTUNITY COST MODULE
* May be replicated, one for each function identified

Figure 2.7--Blaschke's Six Modules of the COST-ED Model

Source: Charles Blaschke, et al., "Performance Contract-Turnkey Approach to Urban School System Reform," EDUCATIONAL TECHNOLOGY, X (September, 1970), 47.

Procedural Models Which Broadly Interpret Cost-Effectiveness

A procedural model was developed by Burgett[40] for making effectiveness/cost evaluations of occupational education. The model consists of eight procedural events taking place within six steps as illustrated in

---

[40] Donald Covel Burgett, "The Development of a Procedural Model for Making Effectiveness/Cost Evaluation of Occupational Education," (unpublished Ph.D. dissertation, Cornell University, 1970).

Figure 2.8. The procedures were applied in a case study of occupational education. The population for the study consisted of graduates of an occupational school, who were compared with a control group of randomly selected graduates from a population of five schools who had participated in a general education curriculum. The inclusion of events 1 through #4 in this procedural model gives cost-effectiveness a broad interpretation. Those events indicate that the analysis includes determining--rather than simply specifying--objectives. Subsequent to determining objectives and identifying behaviors must be the development or selection of alternatives for comparison. This step has been omitted. The analysis process is not described and feedback is not illustrated.

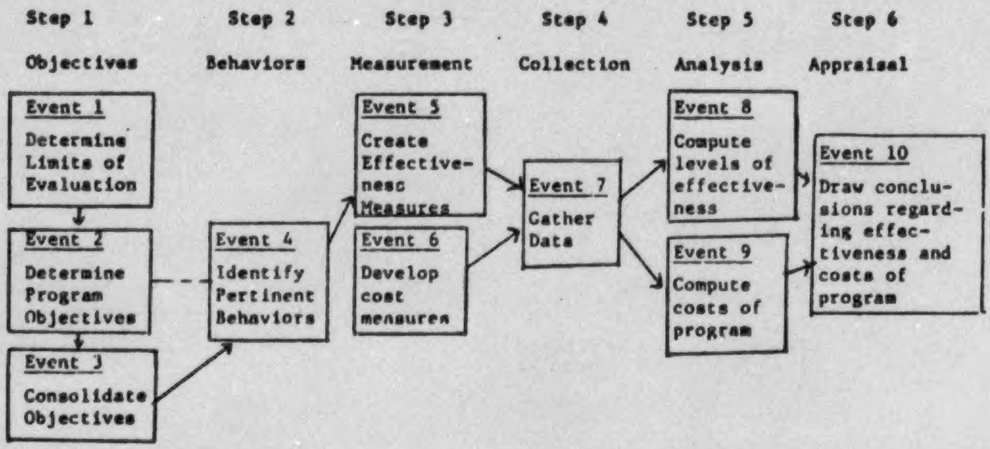
Step 1
Objectives
Step 2
Behaviors
Step 3
Measurement
Step 4
Collection
Step 5
Analysis
Step 6
Appraisal
Event 1
Determine Limits of Evaluation
Event 2
Determine Program Objectives
Event 3
Consolidate Objectives
Event 4
Identify Pertinent Behaviors
Event 5
Create Effectiveness Measures
Event 6
Develop cost measures
Event 7
Gather Data
Event 8
Compute levels of effectiveness
Event 9
Compute costs of program
Event 10
Draw conclusions regarding effectiveness and costs of program

Figure 2.8--Burgett's Procedural Model for Developing Effectiveness/Cost Evaluations of Occupational Education

Source: Donald Covel Burgett, "The Development of a Procedural Model for Making Effectiveness/Cost Evaluations of Occupational Education" (unpublished Ph.D. dissertation, Cornell University, 1970), p. 36.

Doughty designed and implemented an analysis model to predict the cost-effectiveness of competing alternatives rather than conduct a post facto comparison. A longitudinal study was conducted to assess the costs and effectiveness of an instructional development project in college level geology. The alternative approaches included small group instruction, large group lecture-lab, and individualized instruction with commercially produced material. Doughty's model was differentiated into five process phases:[41]

(1) Descriptive Assessment. This involves assessing the cost, effectiveness and feasibility of continuing an on-going instructional system and of constructing a data base using some type of estimation if the alternative is non-operational.

(2) Effectiveness - Feasibility - Cost Relationship Analysis. This involves relating resources to costs and costs to effectiveness measures, including the specification of constraints and capabilities that limit or enhance a system's effectiveness and the use of tabular array or data matrix accompanied by appropriate statements and supporting documentation.

(3) Definition and Specification of Alternatives.

(4) Comparative and Evaluation of Alternatives. An effectiveness - feasibility - cost comparison matrix is suggested as a functional format to aggregate, integrate, and differentiate data and alternatives.

(5) Decision Making.

Cary[42] developed an instructional cost-effectiveness analysis model which was designed in the form of a systems manual. It contains policy statements, an illustrative organizational chart, a flow chart graphically showing the sequence and relationship of activities (see Figure 2.9), and flow script procedures that specify the interrelated work steps. The model purports to assist school personnel in 1) stating the educational need, 2) identifying the objectives, 3) defining the constraints, 4) generating alternative configurations to achieve the objectives within constraints, 5) determining the cost and effectiveness of potential alternatives to allow selection of the optimal alternative, 6) planning implementation strategies, 7) evaluating the performance of the alternative implemented, 8) using feedback results for modification and replanning, 9) providing timely, relevant information for decision makers, 10) documenting the design, analysis and operation of the system, and 11) identifying the role of school personnel in the design and analysis of curriculum. The model emphasizes the operational and implementation aspects of cost-effectiveness analysis within a broad planning scheme. It provides for the prediction of program success and costs of several alternatives, but only operationalizes one alternative. It does not spell out the dynamic interaction of the cost and effectiveness analysis components.

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[41] Philip Leslie Doughty, "Effectiveness, Cost and Feasibility Analysis of Course in College Level Geology" (unpublished Ph.D. dissertation, The Florida State University, 1972).

[42] Francis G. Gary, "Development of an Instructional Cost-Effectiveness Analysis Model for Use in School Districts" (unpublished Ed.D. dissertation, State University of New York at Buffalo, 1972).

Lovell[43] expressed a concern that most studies designed to determine

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[43] Ned Broward Lovell, "Cost-Effectiveness Evaluation of Instructional Programs: A Developmental Design (K-12)," (unpublished Ph.D. dissertation, The Florida State University, 1971).

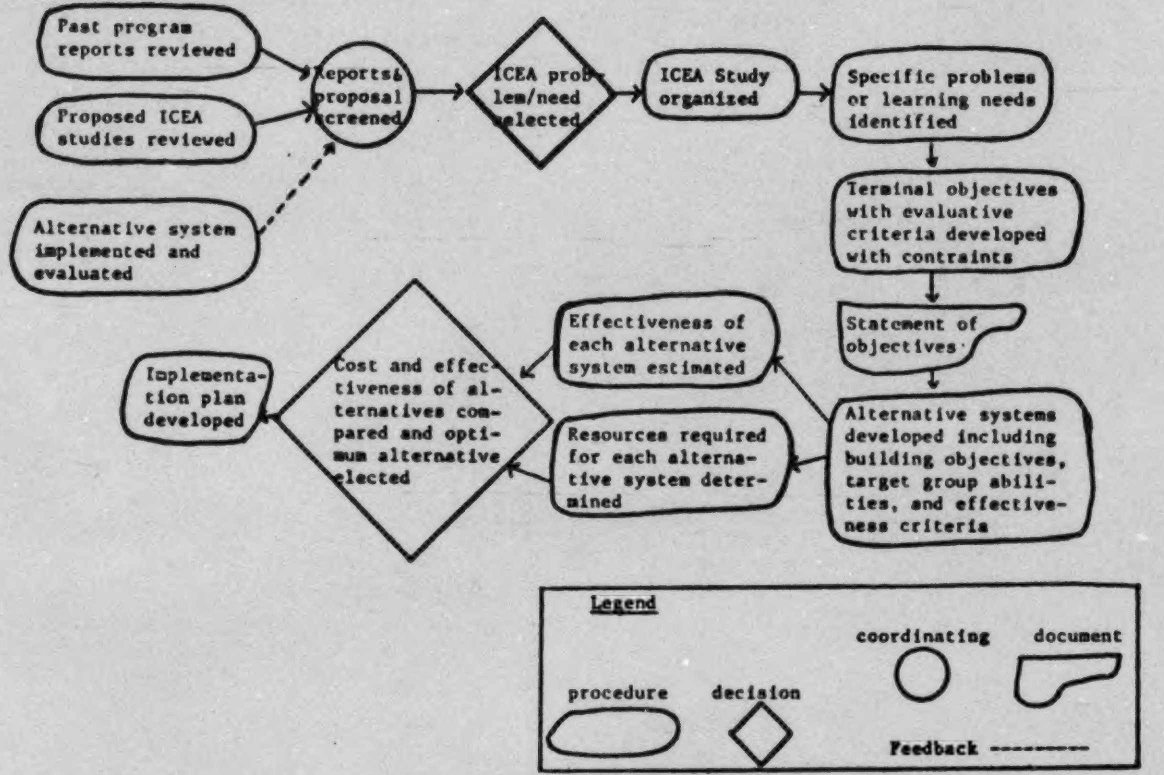
Past program reports reviewed
Proposed ICEA studies reviewed
Alternative system implemented and evaluated
Reports& proposal screened
ICEA problem/need selected
ICEA Study organized
Specific problems or learning needs identified
Terminal objectives with evaluative criteria developed with contraints
Statement of objectives
Alternative systems developed including building objectives, target group abilities, and effectiveness criteria
Effectiveness of each alternative system estimated
Resources required for each alternative system determined
Cost and effectiveness of alternatives compared and optimum alternative elected
Implementation plan developed
Legend
coordinating
document
procedure
decision
Feedback ---------

Figure 2.9--Cary's Flowchart of an Operational Instructional Cost-Effectiveness Analysis (ICEA) Model

Source: Francis G. Cary, "Development of An Instructional Cost-Effectiveness Analysis Model for Use in School Districts," (unpublished Ed.D. dissertation, State University of New York at Buffalo, 1972), p. 109.

the results of particular allocation strategies lacked theoretical orientation, employed limited samples, applied experimental treatment for only a short time before attempting to measure results, failed to introduce necessary controls for extraneous variables, and focused on learning outcomes to the neglect of other possible dependent variables. He concluded that the literature offered little methodological assistance to those who wished to evaluate instructional programs. Lovell's process model consists of nine elements which he expanded (see Figure 2.10) to provide a methodological and conceptual guide in the process of evaluating instructional programs. The nine elements are:

(1) assessing needs;

(2) setting objectives;

(3) identifying constraints;

(4) generating feasible alternatives;

(5) developing criteria for selection;

(6) selecting fixed-cost or fixed-effectiveness approach;

(7) developing models to facilitate the evaluation of alternatives;

(8) analyzing the alternative systems; and

(9) documenting the rationale, assumptions, and analyses involved in the previous steps.

Lovell's model is broad, for it begins cost-effectiveness at the problem awareness stage of systems analysis and concludes at the decision implementation stage. Although his model provides the most complete sequence and relationship of steps in making cost-effectiveness evaluations, the model provides little understanding of the factors and the relationship

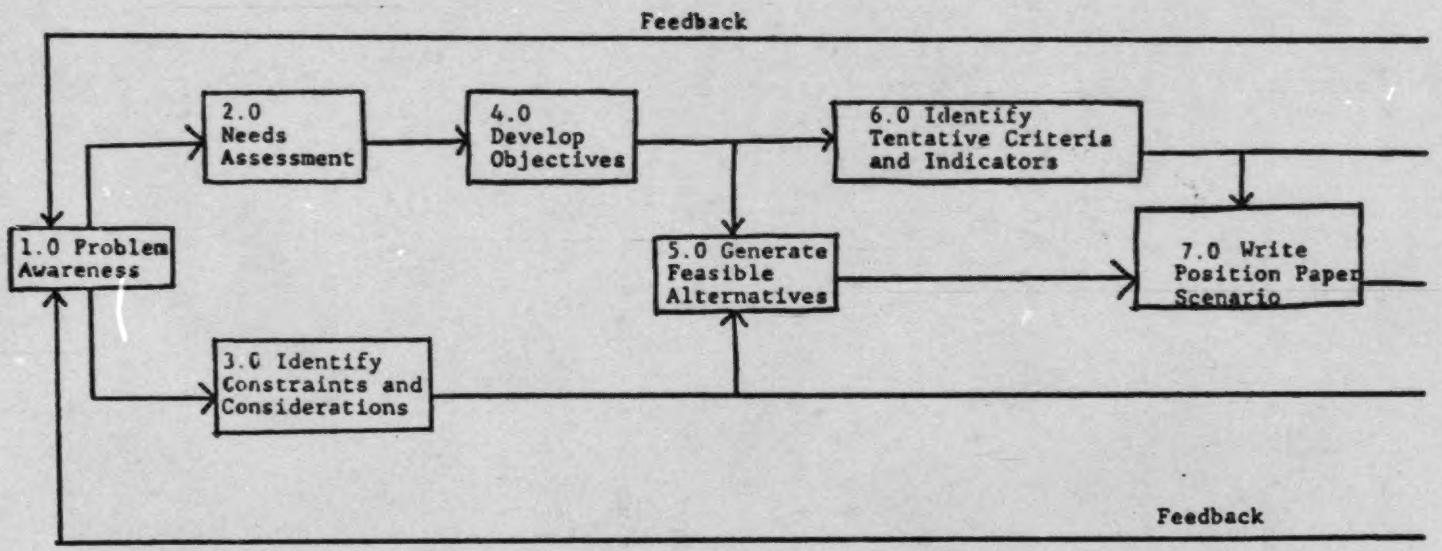
Feedback
2.0 Needs Assessment
4.0 Develop Objectives
6.0 Identify Tentative Criteria and Indicators
1.0 Problem Awareness
5.0 Generate Feasible Alternatives
7.0 Write Position Paper Scenario
3.0 Identify Constraints and Considerations
Feedback

Figure 2.10--Lovell's Methodological and Conceptual Guide In The Process of Evaluating Instructional Programs

Source: Ned Broward Lovell, "Cost-Effectiveness Evaluation of Instructional Programs: A Developmental Design (K-12)," (unpublished Ph.D. dissertation, The Florida State University, 1971), p. 79.

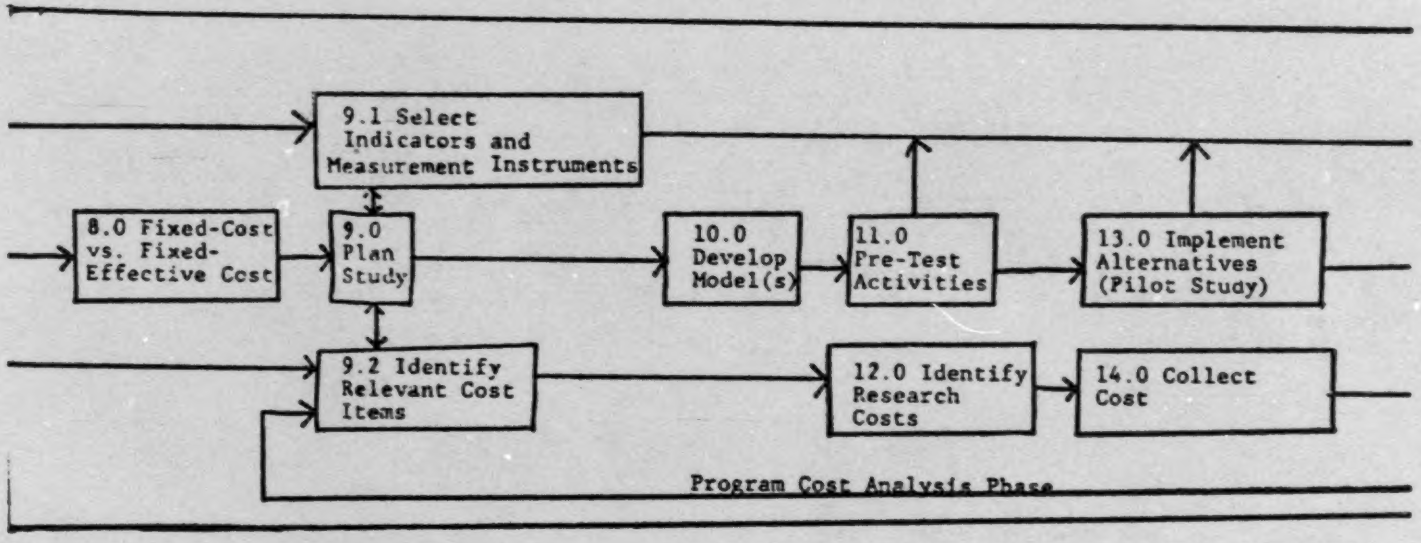
9.1 Select Indicators and Measurement Instruments
8.0 Fixed-Cost vs. Fixed-Effective Cost
9.0 Plan Study
10.0 Develop Model(s)
11.0 Pre-Test Activities
13.0 Implement Alternatives (Pilot Study)
9.2 Identify Relevant Cost Items
12.0 Identify Research Costs
14.0 Collect Cost
Program Cost Analysis Phase

Figure 2.10--p. 2.

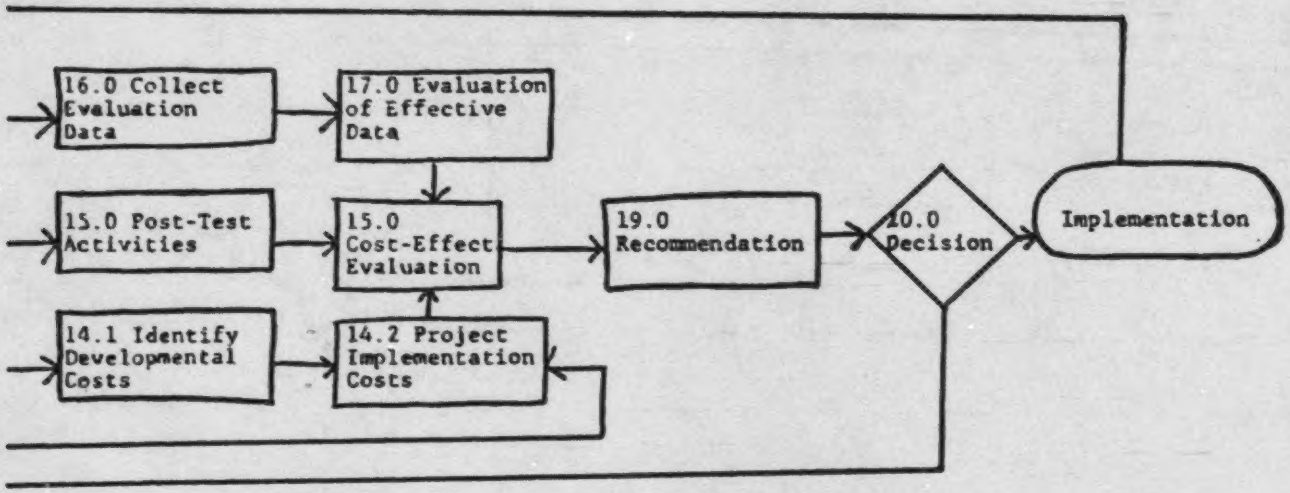
16.0 Collect Evaluation Data
17.0 Evaluation of Effective Data
15.0 Post-Test Activities
15.0 Cost-Effect Evaluation
19.0 Recommendation
20.0 Decision
Implementation
14.1 Identify Developmental Costs
14.2 Project Implementation Costs

Figure 2.10--p. 3.

of factors that must be considered within both the cost and effectiveness dimensions of the analytical process and in the integration of cost and effectiveness values.

Pearson reviewed several hundred documents outside the field of education to determine what cost-effectiveness methods were available, how they operated, what their characteristics were, and how they differed. He found that the majority of approaches to cost-effectiveness analysis possessed certain common functional elements which could be synthesized into a standard sequential procedural approach as follows:

(1) Review definition of the desired general goals and specific objectives that the design is to meet or fulfill.

(2) Review identification of the parameters or requirements essential for the attainment of the desired goals/objectives.

(3) Review development of the alternatives for accomplishing the goals/objectives/requirements.

(4) Establish the evaluative criteria (measures), for cost and effectiveness, that relate alternative capabilities to the goals/objectives/requirements.

(5) Determine the cost of alternatives in terms of evaluation criteria.

(6) Determine the capabilities of effectiveness of the alternatives in terms of evaluation criteria.

(7) Select fixed-cost or fixed-effectiveness approach.

(8) Create an alternative versus criterion display.

(9) Analyze the merits of the alternatives.

(10) Analyze the uncertainty factors.

(11) Document the rationale, assumptions, and analyses underlying the previous steps and submit findings.[44]

Cost-Effectiveness Studies of Programs Using Experimental Design Approaches

Jamison and others[45] combined cost and performance data from the New York City schools to compare a traditional instructional program (control group) with that same instructional program computer assisted (experimental group). Cost estimates on a per-student basis were obtained by making separate estimates of overall system cost and student utilization rate. Using a standard formula,

$$p = \left[\frac{r(1+r)^n}{(1+r)^{n-1}}\right] I$$

where p = imputed annual cost, I = initial cost, n = lifetime of hardware, and r = prevailing annual interest rate, the imputed annual cost of the computer assisted instruction hardware was computed. The effectiveness of the system was based on arithmetic achievement test scores. Since the researchers intended to test computer assisted instruction with the achievement of low performers, comparable cost-effectiveness data should have been collected on alternative compensatory education techniques in arithmetic.

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[44] Pearson, "Study of Cost-Effectiveness," p. 34.

[45] Dean Jamison, *et al.*, "Estimated Costs of Computer Assisted Instruction for Compensatory Education in Urban Areas," EDUCATIONAL TECHNOLOGY, X (September, 1970), 49-57.

Webster[46] determined cost-effective values for three performance contracted reading programs in the public schools of Grand Rapids, Michigan. Due to the different time allotments for reading activities and unequal class sizes, the inputs of instructional costs were reduced to a common denominator of student minutes of exposure and per-student annual costs for the programs studied were calculated. A pre/post administered achievement test measured student gains in each program. Analysis of variance was used to examine reading achievement gains. The annual cost for reading was divided by the average one-tenth student achievement gain.

The Jamison and Webster studies represent experimental treatment approaches to determining the cost-effectiveness of program alternatives. In experimental research designs, groups of students receiving different treatments are equalized in some manner prior to initiating experimental treatments in the form of instructional alternatives, and the treatment settings are as similar as possible outside of the treatment itself. In this way educational outcomes can be attributed to the influence of each instructional alternative. The assumption in such experimental designs is that the influence of other independent variables on outcome has been distributed randomly between each group, i.e., extraneous and unwanted sources of variance are minimized or controlled by the design. The structure of the research design determines the statistical analyses which may appropriately be used.

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[46] Joan Marie Webster, A COST-EFFECTIVE ANALYSIS OF SELECTED READING PROGRAMS IN THE GRAND RAPIDS PUBLIC SCHOOLS, ED 063583 (Washington, D.C.: Educational Resources Information Center, 1972).

Cost Effectiveness Studies of Input Utilization Options

Levin[47] examined the cost-effectiveness of teacher verbal ability as opposed to teacher experience. He was concerned that cost-effectiveness studies had done little to delineate the most effective strategies for purchasing school resources. He posed two questions:

1. Which teachers' characteristics show a relation to a goal that most of us would accept for the schools, that is performance on a standardized test of verbal achievement.
2. What does it cost the schools to obtain teachers with different characteristics.

Levin used production functions in his cost-effectiveness analysis:

(1) The first question was answered by $A = F(X, Y, Z_1, \dots Z_k)$, where A is the achievement score for an individual; X represents a vector of social class and background influences which affect achievement, Y represents a vector of nonteacher characteristics for the schools, and $Z_1, \dots, Z_k$ represents a vector of teacher attributes.

(2) Corresponding to Question 2 would be budget constraint, $B = (P_1Z_1 + P_2Z_2 + \dots + P_kZ_k)$ which applies only to those teachers' costs, where $P_1, \dots, P_k$ denote the prices of teacher characteristics $Z_1, \dots, Z_k$ respectively.[48]

The solution to the problem requires obtaining each type of teachers' quality Z_1 until its additional contribution to achievement relative to its price (P_i) were equal for all Z_i ($i = 1, \ldots, k$), Levin suggested that analysts should provide information as to which teacher characteristics represent "best buys" in improving achievement scores within the confines of a limited budget. He estimated the output in student verbal score for each additional unit of teacher verbal score and experience. He then estimated the relationship between teachers' salaries and teachers' characteristics for linear and non-linear forms of the equation. He compared the relative costs of increasing student verbal achievement score by one point for each strategy and concluded that obtaining highly verbal teachers was more cost-effective than obtaining experienced teachers if the primary objective is to maximize the verbal achievement of students. This study represents a cost-effectiveness analysis of various inputs provided for a school, not of alternative programs used in the schools.

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[47] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," JOURNAL OF HUMAN RESOURCES, 1 (1970), 25-33.

[48] *Ibid.*, 27.

The Institute for Research on Human Resources[49] studied the cost-effectiveness of vocational education. Academic or college preparatory, general, vocational-academic, vocational-comprehensive and vocational technical programs were compared. Major steps in the study were: (1) identification of costs and benefits, (2) collection of representative data, (3) determination of appropriate criteria for investment decisions, (4) statistical analysis, (5) calculation of the return, and (6) consideration of limitations and related issues. Data were collected in three cities. The dependent variables were average monthly earnings, before and after taxes, one and six years after graduation and percent of time employed one and six years after graduation. Other non-monetary and non-economic benefits and performance characteristics such as voting behavior and economic aspirations also were examined. Although the researchers used regression analysis to control for relevant socio-demographic and other variables in making comparisons between these groups, the researchers admittedly could not make a claim that any one of these groups was a theoretically unique control group from any one of the others.

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[49] Teh-wei Hu, et al., A COST-EFFECTIVENESS STUDY OF VOCATIONAL EDUCATION, (University Park, PA: Institute for Research on Human Resources, Pennsylvania State University, 1969).

> It is also quite clear that the independent variables used in this study do not effectively account for all of the differences between the five curriculum groups. And, certainly, the regression analysis does not control perfectly for the differing patterns of interaction among the socio-demographic variables either within or among curriculum groups.[50]

A study was conducted by Holladay[51] to determine if, by controlling the utilization of personnel, services, materials and equipment within schools, higher educational goals would be achieved. Three groups of first grade pupils received different treatments, that is, varying amounts and kinds of resources. Achievement was compared using a pretest-posttest, control group research design to determine if there was a relationship between the resources applied and student achievement gain.

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[50] Ibid., p. 95.

[51] Charles E. Holladay, "A System Approach to Cost-Effectiveness in the Use of Personnel Services, Materials and Equipment for First Grade Pupils in the Tupelo, Mississippi, Public Schools" (unpublished Ed.D. dissertation, University of Mississippi, 1969).

An inverse relationship was found. The researcher suggested that future studies should define instructional programs more completely to provide a greater list of potential contributory variables and should control more variables.

Kiesling[52] estimated the cost-effectiveness of educational inputs in the reading performance of disadvantaged children in California Title I projects. Multiple regression analysis was used to estimate the effect of one instructional resource while holding constant the effects of other explanatory variables in the regression model, such as instructional time, program coordination, pupil socio-economic characteristics, program length, and pupil pretest score as a proxy for ability. Variables were chosen or omitted from the model on the basis of their explanatory power. The linear form of regression represented the greatest total explanatory power of all chosen variables. For each instructional input, the additional reading achievement gain per month, and per week, per ten minutes of instruction per pupil were estimated. The additional achievement gain per month of instruction was calculated for each $100 spent per pupil across each instructional input. This study represents an application of input-output analysis in determining the cost-effectiveness of school resources.

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[52] Herbert J. Kiesling, SOME ESTIMATES FOR THE COST-EFFECTIVENESS OF EDUCATIONAL INPUTS FOR READING PERFORMANCE OF DISADVANTAGED CHILDREN IN CALIFORNIA TITLE I PROJECTS, ED 06861 (Washington, D.C.: Educational Resources Information Center, 1972).

Abt[53] developed an evaluation model for comparing curriculum materials. He established a rating system for calculating both qualitative scores and cost-effectiveness scores for each set of materials being reviewed. Quality was based on the materials' coverage appropriateness and motivational effectiveness. Through a specially designed weighting system, the model allows evaluators to determine and assign weights to qualitative categories and their components on the basis of the needs and goals of the actual schools, students, and teachers who will be using the materials. Some components lend themselves more to objective ranking than others, but much in the weighting and ranking process relies on the evaluator's or evaluation group's judgement. The overall cost-effectiveness measurement adds the cost dimension to curriculum material quality and is derived by dividing overall qualitative effectiveness by actual per pupil cost. Abt's evaluation model is based on a perception of the quality of material inputs into the institutional process, not on the input of the instructional process on actual student output.

Cost-Effectiveness of Instructional Programs and Processes in a Non-Experimental Setting

Deloria[54] and his associates established a design for a national day care cost-effectiveness experiment. Comparisons would be made of day care structure (e.g., family home vs. center), caregiver training (e.g., formal vs. informal programs), program type (i.e., formal program #1 vs. #2 vs. #3), caregiver/child ratio (i.e., 1:6 vs. 1:10 vs. 1:15), and combinations of the above. For the purposes of distinguishing among curricula, guidelines for specifying curricular and program objectives and variables for each curriculum analyzed would be combined into a gloabl list. These guidelines are to reflect the curriculum planner's conceptions of the key dimensions of each curriculum. The analysis includes: combining recommended independent variables into an explicit design in which the effects of potentially confounding variables are accounted for; collecting and processing dependent variables; and discussing the multivariate nature of the analyses needed to provide answers to the cost-effectiveness questions. Multivariate analysis of variance is the recommended statistical procedure. Additional steps specify cost-assessment procedures and measurement, and accounting and pricing considerations.

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[53] Clark C. Abt, "How to Compare Curriculum Materials," NATION'S SCHOOLS, 86 (July, 1970), 21-28.

[54] Dennis J. Deloria, *et al.*, A DESIGN FOR A NATIONAL DAY CARE COST-EFFECTIVENESS EXPERIMENT, Final Report, (Ypsilanti, MI: High/Scope Educational Research Foundation, 1972).

A comparison of between and within program effects include overall effects on the child, family, community, and teacher. Cost-effective comparisons include:[55]

(1) determining a) if there are any obviously superior and inferior programs, that is, programs with lower and higher than average costs, and b) what specific

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[55] Ibid., pp. 4-31 and 4-32.

combinations of causes differentiate superior and inferior programs using the process and operational data collected on these programs;

(2) determining the degree of consistency over time between adjusted costs and relative effects by replicating the study, thereby establishing norms on the cost and effects profiles;

(3) comparing the normed cost-effect profiles for:
a) informal programs vs. formal programs;
b) family home programs vs. the center programs;
c) three different formal programs with each other; and
d) programs having the different caregiver/child ratios with each other; and

(4) determining the cost for each unit of effect through the use of cost analysis and specific effects data and comparing these figures after replication between the different program types, program structures, and caregiver/child ratios to identify the most cost-effective components over all programs.

Curtis[56] applied a cost-effectiveness technique to reading projects in the Milwaukee Public Schools. Two particular reading projects were selected because they were located in the same geographical area, contained similar student populations, shared similar objectives, and possessed common process (components) for comparison. The researchers intended first to rank order the most important objectives and then to rank order the processes (components) which were perceived by a panel of judges as making the greatest contribution to the attainment of those objectives. A utility/cost value of each process was calculated by dividing the utility value by the per pupil cost for the process. The proportion of contribution for each process to overall average effectiveness was determined by dividing the utility value of each process by the sum of all utility values for all processes. When the overall effectiveness score was multiplied by the proportion of contribution of each process, the effectiveness value of each process was obtained. To obtain a cost-effectiveness ratio for each process, the process effectiveness value was divided by the per-pupil cost of each process. This provides an estimate on how much gain achievement can be associated with a dollar of investment in each process. Figure 2.11 displays the manner for determining the cost-effectiveness of each process.

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[56] Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, pp. 241-265.

PROPORTION OF CONTRIBUTION TO EFFECTIVENESS			DISTRIBUTION OF EFFECTIVENESS VALUE TO PROCESS		COST TO EFFECTIVENESS RATIO
Process	Utility	Proportion of Contribution	Process	Value	
K	212	.15	K	.41	$ 6.00/.41
A	205	.15	A	.41	$ 5.63/.41
G	192	.14	G	.38	$ 21.00/.33
B	169	.12	B	.33	$ 5.62/.33
I	141	.10	I	.27	$ 50.00/.27
F	117	.08	F	.22	$ 49.00/.22
J	116	.08	J	.22	$ 5.00/.22
E	112	.08	E	.22	$161.00/.22
H	75	.05	H	.14	$ 21.00/.14
C	75	.05	C	.14	$ 38.00/.14

Overall Effectiveness Score = 2.74

Figure 2.11--Curtis' Process Cost-Effectiveness Illustration

Adapted from: William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM (Chicago: Research Corporation, Association of School Business Officials, 1971), p. 258.

The researchers suggested using a Q-Sort technique for rating objectives and processes in order to eliminate ordinal ranks and to add a dimension of quantitative importance, and added that the procedure could also be used to identify the cost-effectiveness of processes for student target populations. Curtis' contribution may be helpful when calculating the cost-effectiveness of program components after overall cost and effectiveness values have been gathered. The process effectiveness scores are subjectively estimated, however. He did not deal with the analytical process for deriving those cost and effectiveness values.

Summary

Cost-effectiveness analysis is an evaluative technique based upon economic and systems theory which recently has been applied to maximize the results obtained from the allocation of scarce resources in education. The results of cost-effectiveness analysis assist in determining which alternative ways to allocate resources are most productive in reaching educational objectives. The costs and effectiveness of each alternative are measured and integrated in a manner which allows for comparison among alternatives to determine which alternative is the most productive.

The basic elements and procedures of cost-effectiveness analysis have been specified. The confusion over precisely which elements and procedures are included in cost-effectiveness analysis is a result of the various perceptions of the relationship between the technique and the entire systems approach to planning and analysis. If the analysis is given a broad interpretation, then the development of educational objectives and the generation of alternatives to achieve those objectives are requisite components, in addition to the generation and integration of cost effectiveness values. When the analysis is given a narrow interpretation, objectives and alternatives that have been previously developed are merely described using a common format. (This is in addition to the generation and integration of cost and effectiveness values.) Cost and effectiveness values may be predicted or measured after the fact.

There is general agreement that, although the use of cost-effectiveness analysis is not an exact science, it does reduce the margin of error in decision making. It does not, however, substitute for judgment and intuition and, as such, is simply one informational element in the decision process. It can not substitute completely for judgment and intuition; for some cost-effectiveness considerations, as well as considerations external to the analysis itself, are non-quantifiable.

Cost-effectiveness analysis may be applied at various levels of an educational system to compare 1) the relative worth of programs, 2) program(s) over time, and 3) the relative worth of programs for different student populations. The analysis can be altered to examine the relative effectiveness of alternatives at fixed budgetary levels, the relative cost of alternatives at fixed effectiveness levels, or the most productive utilization of resources with neither cost nor effectiveness held constant.

Several cost-effectiveness models have been proposed and a number of studies have been conducted. They are distinguishable by their various applications, interpretations of the boundaries of the analysis, and research designs and/or procedures. The critique and integration of the various models and procedures will be dealt with further in Chapter III as they relate to the purpose of the study.

CHAPTER III

PRODUCTIVITY IN EDUCATION

In this chapter the literature on productivity in education is reviewed. The chapter expands upon the concept and measurement of productivity which was introduced in Chapter I. The application of productivity to cost-effectiveness studies was discussed in Chapter II wherein the technique of input-output analysis was used to test the cost-effectiveness of input utilization options. The review includes a discussion of 1) graphic and mathematical models of productivity, 2) analytical problems encountered in input-output analyses, and 3) research findings obtained from studies which have been conducted to determine the impact of school and non-school inputs on student outputs.

Models of Productivity

Several graphic and mathematical models of productivity exist in the literature which attempt to explain the cause-effect relationship of resources (inputs) from the external environment to student outputs and school inputs to student outputs. Mathematical models are applied in statistical analyses to measure the strength of the influence of various inputs on output relative to other environmental and school resources.

Alternative Basic Graphic Models

Thomas[1] distinguished three basic models which attempt to explain the nature of the interaction between environmental effects, school effects, and outputs. In the additive model, the impact of the environment and school on outputs are viewed as separate, but additive (see Figure 3.1). Through the use of input-output analysis, an attempt is made to examine the relationship between a single independent resource variable on the dependent variable of output by controlling or holding constant other independent variables.

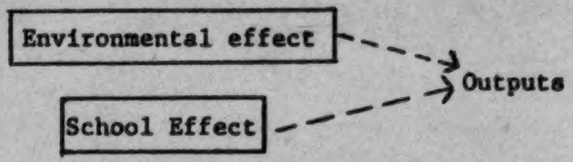

Figure 3.1—An Additive Model of School and Environmental Effects on Learning.

Source: J. Alan Thomas, THE PRODUCTIVE SCHOOL, (New York: Wiley, 1971), p. 7.

Thomas viewed the open systems model as the more realistic of the two (see Figure 3.2). The environment is viewed as affecting the nature of both the school effects and outputs. In this case, all variables are examined simultaneously rather than holding certain variables constant as others are examined. The effect of a combination of inputs or an analysis of the changes in the inputs, processes, and outputs of a single educational system over long periods of time are observed.

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[1] J. Alan Thomas, THE PRODUCTIVE SCHOOL: A SYSTEMS ANALYSIS APPROACH TO EDUCATIONAL ADMINISTRATION, (New York: Wiley, 1971), pp. 17-19.

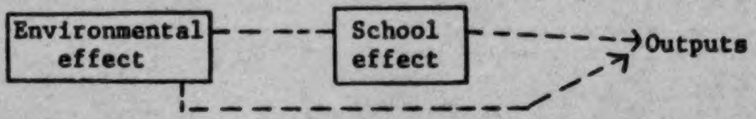

Figure 3.2--An Open Systems Model of School and Environmental Effects on Learning.

Source: J. Alan Thomas, THE PRODUCTIVE SCHOOL,(New York: Wiley, 1971), p. 18.

The interactive model (see Figure 3.3), Thomas asserted, is the most adequate as an explanatory device. In the model, the environment and the school intersect. Thomas proposed the development of a mathematical procedure, which may involve the solution of a complex set of simultaneous equations, to determine relationships using this model.

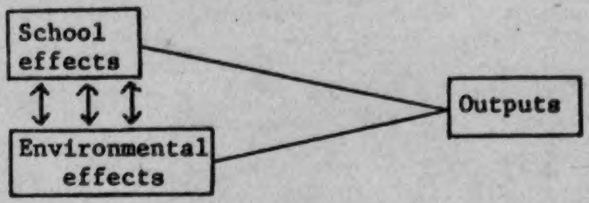

Figure 3.3--An Interactive Model of School and Environmental Effects on Learning.

Source: J. Alan Thomas, THE PRODUCTIVE SCHOOL,(New York; Wiley, 1971), p. 18.

analysis of the changes in the inputs, processes, and outputs of a single educational system over long periods of time are observed.

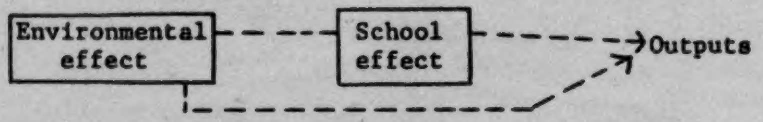
Environmental effect
School effect
Outputs

Figure 3.2--An Open Systems Model of School and Environmental Effects on Learning.

Source: J. Alan Thomas, THE PRODUCTIVE SCHOOL,(New York: Wiley, 1971), p. 18.

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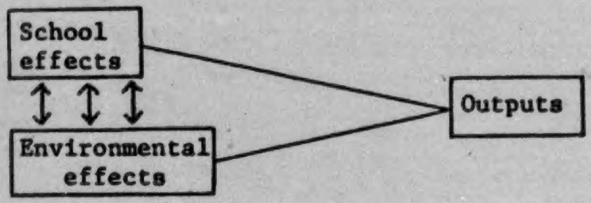
School effects
Environmental effects
Outputs

Figure 3.3--An Interactive Model of School and Environmental Effects on Learning.

Source: J. Alan Thomas, THE PRODUCTIVE SCHOOL,(New York; Wiley, 1971), p. 18.

formal expression of this production function may be specified as:

(2) $0 = a + b_1 r_1 + \ldots + b_n r_n + c_1 f_1 + \ldots + c_m f_m + d_1 p_1 + \ldots + d_k p_k$ where b_1, c_1, and d_1, denote the unit contribution of their respective factors.[3]

Multiple regression analysis has been used to estimate the values of the coefficients b , c , and d and provides for tests of the "significance" of the empirical results.

Simultaneous Equation Model

Levin has proposed a model to solve a complex set of simultaneous equations which may explain the nature of environmental and school effects on outputs posed by the interactive model illustrated by Thomas earlier. Levin conceived of a model wherein every variable depends on every other variable, that is, the existence of simultaneity. For example, he illustrated the interdependence of student achievement, student motivation, student efficacy, and parents' attitudes in Figure 3.4,

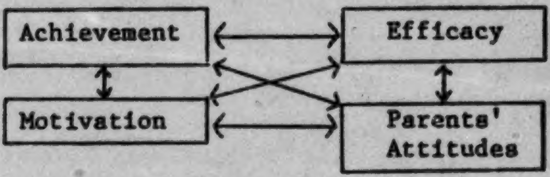

Figure 3.4--Levin's Illustration of Input-Output Simultaneity

Source: Henry M. Levin, A NEW MODEL OF SCHOOL EFFECTIVENESS, Research and Development Memorandum No. 63, (Stanford, CA: Stanford Center for Research and Development Teaching, School of Education, Stanford University, 1970), p. 13.

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[3] *Ibid.*, p. 32.

Levin posited that, although such inputs as students' sense of efficacy of fate control, educational motivation, and parents' educational expectations are likely to affect achievement, achievement is also likely to affect those factors. Hence, some inputs may also be viewed as measures of output. In addition, each attitudinal variable is influenced by others. He specified five mathematical equations, the last four of which together comprise the simultaneous equation model. Equation (1) views a student's academic performance as a "function of the amount of different kinds of capital embodied in him . . . by his family, school, community, peers, as well as his innate traits."[4] Equation (1), the capital embodiment model, is essentially the typical educational production function mentioned earlier:

$$(1)\quad A_{it} = g\left[F_{i(t)}, S_{i(t)}, P_{i(t)}, O_{i(t)}, I_{it}\right]$$

where the i subscript refers to the ith student; the t subscript refers to time period t; and the t subscript in parentheses (t) refers to being cumulative to time period t. Thus:

A_{it} = a vector of educational outcomes for the ith student at time t.

$F_{i(t)}$ = a vector of individual and family background characteristics cumulative to time t.

$S_{i(t)}$ = a vector of school inputs relevant to the ith student cumulative to time t.

$P_{i(t)}$ = a vector of peer or fellow student characteristics cumulative to time t.

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[4] Henry M. Levin, A NEW MODEL OF SCHOOL EFFECTIVENESS, Research and Development, (Stanford, CA: Stanford Center for Research and Development in Teaching, School of Education, Stanford University, 1970), p. 10.

$O_{i(t)}$ = a vector of other external influences (community, etc.) relevant to the ith student cumulative to time t.

I_{it} = a vector of initial or innate endowment of the ith student at time t.

It is assumed that g is positve for all these arguments, or that the marginal product of additional capital embodiment from any one of the five sources has a positive effect on student educational outcome.[5]

In Equation (2) Levin added the postulate that educational achievement is likely to be a function of the students' and parents' attitude toward education in addition to the independent variables already identified in Equation (1) so that:

$$(2)\quad A_{1_{it}} = g\left[F_{i(t)}, S_{i(t)}, P_{i(t)}, O_{i(t)}, I_{i(t)}, A_{2_{it}}, A_{3_{it}}, A_{4_{it}}\right]$$

$A_{1_{it}}$ = the achievement level of the ith student at t.

$F_{i(t)}$, $S_{i(t)}$, $P_{i(t)}$ and $O_{i(t)}$ are as previously defined.

$A_{2_{it}}$ = a measure of the ith student's sense of efficacy or fate control at t.

$A_{3_{it}}$ = a measure of educational motivation of the ith student at t.

$A_{4_{it}}$ = parents' educational expectations for the ith student at t.[6]

In order to demonstrate all interdependencies conceptualized in Figure 3.4, equations (3) through (5) are postulated which, in addition to equation (2), formulate the simultaneous equation model:

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[5] Ibid., pp. 10-11.

[6] Ibid., pp. 11-12.

$$(2)\ A_{1_{it}} = g_1 \left[F_{1_{i(t)}}, S_{1_{i(t)}}, P_{1_{i(t)}}, O_{1_{i(t)}}, I_{1_{it}}, A_{2_{it}}, A_{3_{it}}, A_{4_{it}} \right.$$

$$(3)\ A_{2_{it}} = g_2 \left[F_{2_{i(t)}}, S_{2_{i(t)}}, P_{2_{i(t)}}, O_{2_{i(t)}}, I_{2_{it}}, A_{1_{it}}, A_{3_{it}}, A_{4_{it}} \right.$$

$$(4)\ A_{3_{it}} = g_3 \left[F_{3_{i(t)}}, S_{3_{i(t)}}, P_{3_{i(t)}}, O_{3_{i(t)}}, I_{3_{it}}, A_{1_{it}}, A_{2_{it}}, A_{4_{it}} \right.$$

$$(5)\ A_{4_{it}} = g_4 \left[F_{4_{i(t)}}, S_{4_{i(t)}}, P_{4_{i(t)}}, O_{4_{i(t)}}, I_{4_{it}}, A_{1_{it}}, A_{2_{it}}, A_{3_{it}} \right.$$

> . . . It should be noted that the specification of each of the exogenous variables is unique in each relation. That is, it is reasonable to believe that different family factors, school factors, innate characteristics, and so on, affect achievement ($A1_{it}$) than affect the other endogenous variables, ($A2_{it}$), ($A3_{it}$), and ($A4_{it}$). Accordingly, $F1_{i(t)}$ is considered to be a different vector of family influences than $F2_{i(t)}$, $F3_{i(t)}$, and $F4_{i(t)}$. The potential uniqueness of $S_{i(t)}$ for each equation is is also represented by the appropriate subscript as well as the uniqueness of the other vectors. It is particularly useful if one can distinguish between school characteristics that relate to achievement ($A1_{it}$) and those that relate to student and parental attitudes.[7]

A Model to Compare Curricular Variables

Quilling[8] proposed the use of a regression equation analysis model to determine the effect of certain curricular variables on student achievement. She wanted to discover the conditions within a curriculum that were associated with various outcomes. The model included both pupil and curricular variables. Quilling identified four curricular variables which described the instructional process and content characteristics. Both instructional process and content characteristic variables were found to be useful predictors of achievement.[9]

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[7] *Ibid.*, pp. 14-15.

[8] Mary R. Quilling, "A Data Analysis Approach to Evaluating Achievement Outcomes of Instruction," (unpublished Ph.D. dissertation, University of Wisconsin, 1973).

Instructional Process Variables

(1) Curriculum decision unit size--relates to the amount of curriculum content included in each student assessment decision.

(2) Rate adaptiveness--relates to the degree to which instruction in several ways is adapted to the student, that is, a measure of degree of individualization.

Content Characteristic Variables

(3) Structural granularity of the content--relates to the organization of content within curricular decision units.

(4) Puissance--relates to the degree of higher order behaviors represented in the curriculum completely defined by objectives, that is, a measure of content difficulty.

In Quilling's initial screening of these variables, only puissance failed to discriminate among the various programs studied. Quilling's use of a regression equation to study the impact of curricular variables on student output represents a departure from the traditional use of such equations. Typically, regression equations measure the impact of school inputs or input utilization options on achievement. Quilling added several curricular variables to pupil input variables to represent the independent variables in educational production and to partial out the effectiveness of those curricular variables.

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[9] *Ibid.*, pp. 64-74.

Models Focusing on Specific Input-Output Relationships Under Study

Productivity models conceived by Bidwell and Kasarda and Wiley and Harnischfeger contain only those environmental and/or school input components which assist the researcher in examining particular relationships under study. Bidwell and Kasarda examined the relationship between school district structural variables, environmental variables, and output variables for the purpose of

> . . .know[ing] whether, to what extent, [and] in what ways, the organizational structure of school districts act to convert resource inputs and other types of inputs (for example, parental preferences and social characteristics of families from which students come) into outputs, in this case outputs of cognitive attainment.[10]

In addition, by using school districts rather than schools as the unit of analysis, Bidwell could examine certain organizational variables (administrative intensity and professional support) whose properties are not measurable at the school level. Figure 3.5 illustrates the variables studied and the significant relationships found. Bidwell and Kasarda examined the direct effects of environmental variables using a path analysis technique. They found that the direct effect of larger size and more resources on outputs was small but when linked with certain structural variables became significant. Import causal chains identified by Bidwell and Kasarda are illustrated in Figures 3.6 and 3.7.

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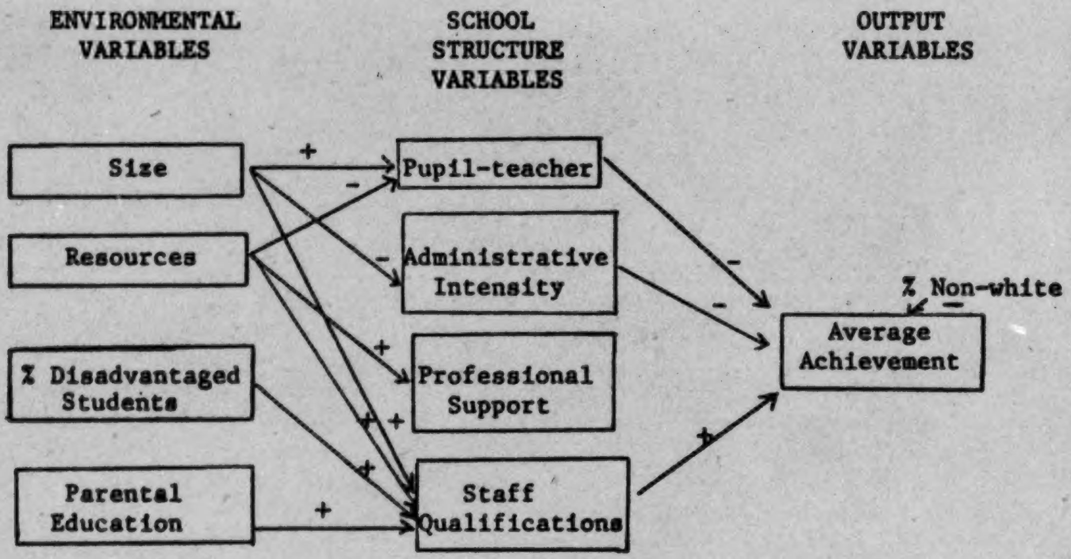
[10] Charles E. Bidwell, edited version of an interview, "The Relationship Between School District Organization and Student Achievement," ADMINISTRATOR'S NOTEBOOK, XXIII, 2 (1975), 1.


ENVIRONMENTAL VARIABLES
SCHOOL STRUCTURE VARIABLES
OUTPUT VARIABLES
Size
Resources
% Disadvantaged Students
Parental Education
Pupil-teacher
Administrative Intensity
Professional Support
Staff Qualifications
Average Achievement
% Non-white
+
-
-
+
+
+
+
+
-
-
+
-

Note: A '+' sign means that the variables move together. For example, as size increases, pupil-teacher ratio increases. A '-' sign means that the variables move in opposite directions. For example, as resources increase, pupil teacher ratio decreases.

Figure 3.5--A Model of School District Effects

Source: Charles E. Bidwell, "The Relationship Between School District Organization and Student Achievements," ADMINISTRATOR'S NOTEBOOK, XXIII, 2 (1975), 2.

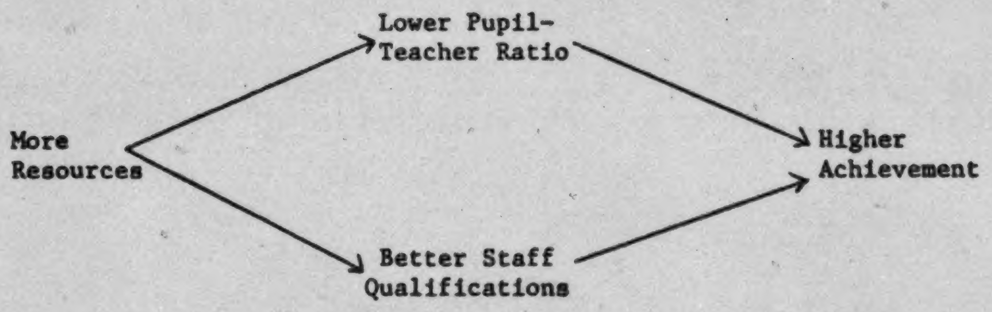

Lower Pupil-Teacher Ratio
More Resources
Higher Achievement
Better Staff Qualifications

Figure 3.6--Resources – Achievement Causal Chain

Source: Charles E. Bidwell, "The Relationship Between Several District Organizations and Student Achievement," ADMINISTRATOR'S NOTEBOOK, XXIII, 2 (1975), 2.

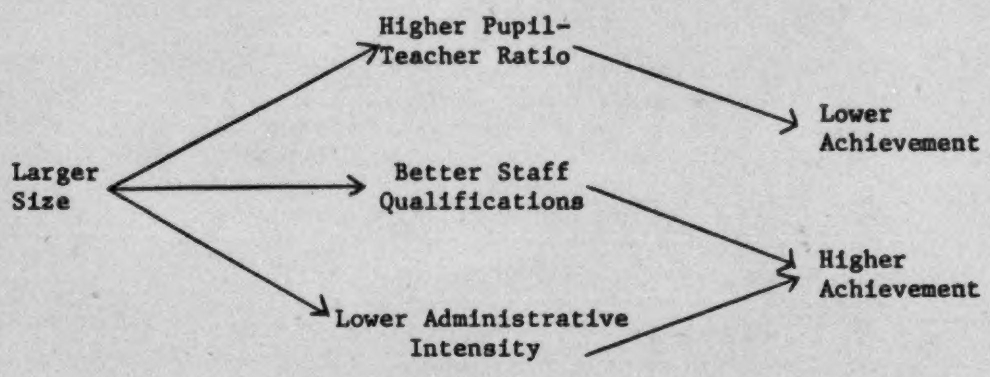

Higher Pupil-Teacher Ratio
Lower Achievement
Larger Size
Better Staff Qualifications
Higher Achievement
Lower Administrative Intensity

Figure 3.7--Size - Achievement Causal Chain

Source: Charles E. Bidwell, "The Relationship Between Several District Organizations and Student Achievement," ADMINISTRATOR'S NOTEBOOK, XXIII, 2 (1975), 2.

Wiley and Harnischfeger[11] developed a definitive model (see Figure 3.9) based upon the assumption that the time in which a student is exposed to schooling and, subsequently, to instruction has a significant impact on achievement. Their model delineates the subcomponents of time and their interrelationships. They began with a causal model (see Figure 3.8) with relatively few elements and refined it by relating the quality of instruction to the amount of time a student is actually exposed to instruction. The model also links individual pupil characteristics, individual pupil attendance, teacher characteristics, and curricular characteristics to exposure time.

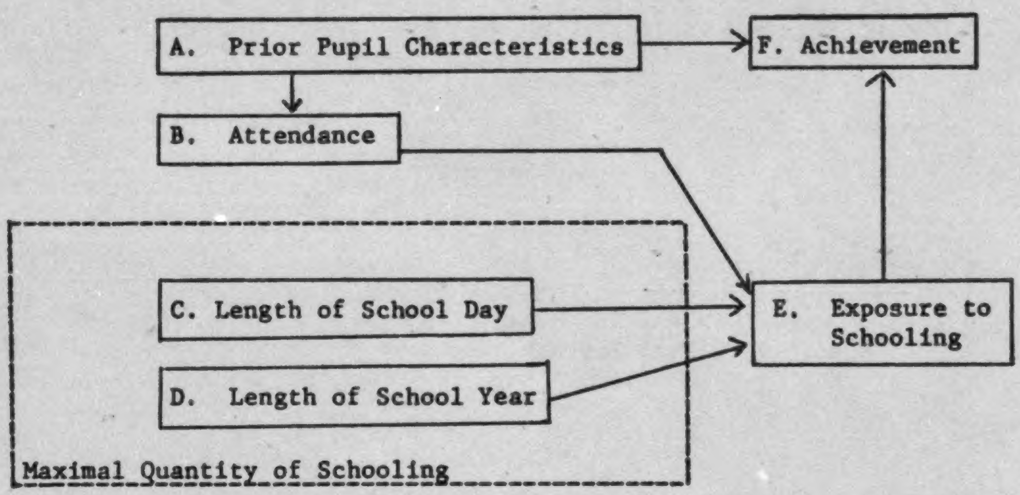

A. Prior Pupil Characteristics
F. Achievement
B. Attendance
C. Length of School Day
E. Exposure to Schooling
D. Length of School Year
Maximal Quantity of Schooling

Figure 3.8--Schooling Exposure and Achievement

Source: David E. Wiley and Annegret Harnischfeger, "Explosion of a Myth: Quantity of Schooling and Exposure to Instruction, Major Educational Vehicles," EDUCATIONAL RESEARCHER, 3 (April, 1974), 7-12.

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[11] David E. Wiley and Annegret Harnischfeger, "Explosion of a Myth: Quantity of Schooling and Exposure to Instruction, Major Educational Vehicles," EDUCATIONAL RESEARCHER, 3 (April, 1974), 7-12.

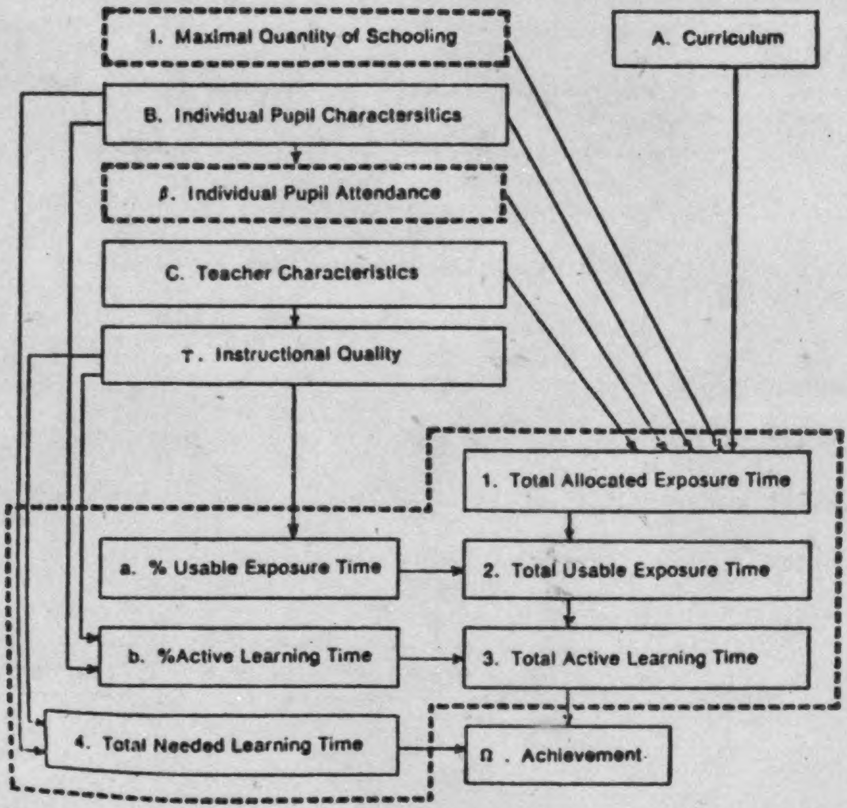
I. Maximal Quantity of Schooling
A. Curriculum
B. Individual Pupil Charactersitics
β. Individual Pupil Attendance
C. Teacher Characteristics
T. Instructional Quality
1. Total Allocated Exposure Time
a. % Usable Exposure Time
2. Total Usable Exposure Time
b. %Active Learning Time
3. Total Active Learning Time
4. Total Needed Learning Time
Ω. Achievement

Figure 3.9--Individual Instructional Exposure and Achievement Model

Source: David E. Wiley and Annegret Harnischfeger, "Explosion of a Myth: Quantity of Schooling and Exposure to Instruction, Major Educational Vehicles," EDUCATIONAL RESEARCHER, 3 (April, 1974), 10.

This model is unique in that all environmental, school input, and curricular content and process variables affect achievement only as they control a student's total needed learning time and total active learning time.

Analytical Problems

Spady, Averch,and Levin among others have encountered analytical problems in productivity studies which tend to limit the definitiveness of their results. Spady[12] linked methodological limitations to four sources: 1) the school setting, 2) multicollinearity, 3) the measurement of variables, and 4) limited and narrow measures of outcome,

The school setting is less than ideal for manipulating school organizational features due to the heterogeneous nature of:[13]

(1) the distribution and utilization of various resources;

(2) the structure and student body composition of schools and classrooms;

(3) the selection of students into schools and programs;

(4) the methods of instruction, evaluation, and promotion; and

(5) the operational goals of such programs.

For example, spurious results are created by missing data observations from a highly mobile student body,

Under such conditions of heterogeneity, it is difficult to meet rigorous experimental research requirements and isolate the impact of independent variables on dependent variables. Since natural experimental conditions rarely exist, researchers must turn to the use of multivariate statistical analyses to attempt to control or hold constant the effects of one or more variables while studying the effects of others. Unfortunately, determining the impact of variables under present analyses is very difficult, since correlations among various resource inputs exist. The existence of this multicollinearity complicates the task of accurately predicting the impact of specific resource inputs when analyzing and interpreting data. Since the world is characterized by nonlinearities, the fitting of data to a linear production function limits accuracy.

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[12] William G. Spady, "The Impact of School Resources on Students," in REVIEW OF RESEARCH IN EDUCATION, Fred N. Kerlinger, ed., (Itasca, IL: Peacock, 1973), pp. 136-37.

[13] *Ibid.*, p. 136.

Measures of supposedly relevant variables are "crude and deceptive" for they are

> . . .selected on an ad hoc basis, are tangible or structural, are crudely and even unreliably measured, stress quantity or mere presence over quality or mode and degree of utlization, and are recognized proxies for presumably more process variables that remain unmeasured.[14]

Levin[15] provided additional examples of this source of methodological limitation. According to Levin, those who would specify an educational production function must rely on intuition and hunch, since a well developed and validated theory of learning to serve as a guide for specifying inputs and their relationships to outputs does not exist. Teacher proficiency as an input is also difficult to measure so that teacher training and experience must suffice as conventional proxies.

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[14] Ibid., pp. 136-137.

[15] Levin, A NEW MODEL OF SCHOOL EFFECTIVENESS, pp. 5-9.

Although several domains of student learning outcomes are recognized, the plethora of research on productivity focuses on measures of cognitive achievement to represent outcome.

Averch[16] added the practice of data aggregation to the list of methodological limitations. Although it would be useful for prescriptive purposes to know the influence of individual environmental and school variables on a particular student's educational outcome, data are not available at this level of analysis. Consequently, data are aggregated by using measures of central tendency. The aggregation of data fails to account for potentially wide variation within resources. These analytical problems will be discussed in greater detail in Chapter V.

Research Findings

Over the last twenty years many productivity studies have been conducted. These studies have sought to identify and measure the influence of human, material, and socio-economic inputs on student output. The following review of research findings from input-output analyses is organized in accordance with the manner in which school and non-school inputs are displayed in a representation of an educational system conceived by Rossmiller, Marinelli, and Geske.[17] Since their conceptual framework of education as a system subject to economic analysis serves as the theoretical model with which the cost-effectiveness analytical model developed in this thesis must be integrated, it is considered the most appropriate way to view the organization of resources for future reference.

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[16] Averch, HOW EFFECTIVE IS SCHOOLING?, pp. 36-37.

[17] Richard A. Rossmiller, Joseph J. Marinelli, and Terry G. Geske, ECONOMIC ANALYSES OF EDUCATION: A CONCEPTUAL FRAMEWORK, Theoretical Paper, (Madison, WI: Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin-Madison, 1975).

Inputs (Resources) to the Educational System from the External Environment

The resources supplied to the educational system from the external environment may be classified as to 1) knowledge, values, and goals that affect the system, 2) population attributes such as demographic and socio-economic characteristics, and 3) economic resources. Several studies have examined the impact of population attributes and economic resources on student outcomes.

Economic Resources

The level of economic resources made available to an educational system from the external environment determines the amount and quality of human and material resources which may be purchased to operate the system's educational program. Studies have been conducted that attempt to relate economic resources, measured as per pupil expenditures, to student outcomes.

Flanagan, *et al.*,[18] reported significant relationships between this predictor variable and pupil achievement, percentage of students going on to college, and school holding power, that is, percentage of students staying in school versus dropping out of school. Ribich,[19] utilizing data on students in the lowest quintile on measures of socio-economic status (SES), found a significant relationships between expenditure per pupil and student output on a standardized achievement test after controlling for other out-of-school variables. According to Burkhead and his associates,[20] however, current expenditures had very little influence on school outputs in Atlanta. The positive association found there between current expenditures and dropout rates suggests that simply allocating more resources will not alleviate the dropout problem.

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[18] John C. Flanagan, *et al.*, STUDIES OF THE AMERICAN SCHOOL, Cooperative Research Project No. 226,(Pittsburgh, Pa.: Project Talent Office, University of Pittsburgh, 1962).

Kiesling[21] found that the relationship of expenditure to performance in large urban districts was quite strong. The addition of $100 of expenditure was associated with 2.6 months of achievement at the beginning of the expenditure range. Goodman, Rajpal, and Mollenkopf and Melville[22] found positive relationships between per pupil expenditures and acadmic achievement. Benson,[23] after examining fifth grade students in populous low and high average achievement California school districts, concluded that a positive relationship existed between per pupil expenditure and student achievement on the basis of the entire sample. Per pupil expenditure was not significant, however, in low average achievement districts. Dunnell[24] concluded that, when per pupil expenditure was combined with SES variables in a stepwise multiple regression procedure--a procedure also used by Benson above--per pupil expenditure added very little to the variance accounted for in his sample of fourth and seventh graders in suburban Cook County, Illinois. Bidwell and Kasarda[25] observed rather strong correlations between economic resources and reading achievement but, after controlling for school variables purchased by those economic resources, no significant relationship was found. Kiesling,[26] in a study of fifth and eight graders from low SES deciles in New York State, found that the total value of school district plant and equipment was related negatively to pupil performance. In a later study, however, he found no relationship between these two variables for a sample cutting across all SES groups.

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[19] Thomas I. Ribich, EDUCATION AND POVERTY, (Washington, D.C.: Brookings Institute, 1968).

[20] Burkhead, et al., INPUT AND OUTPUT IN LARGE CITY HIGH SCHOOLS, (Syracuse, NY: Syracuse University Press, 1967).

[21] Herbert J. Kiesling, "Measuring a Local Government Service: A Study of School Districts in New York State," REVIEW OF ECONOMICS AND STATISTICS, XLIX (August, 1967), 356-367.

[22] S. M. Goodman, THE ASSESSMENT OF SCHOOL QUALITY, (Albany, N.Y.: State Education Department of New York, 1959); Puran L. Rajpal, "Relationship Between Expenditures and Quality Characteristics of Education in Public Schools," JOURNAL OF EDUCATIONAL RESEARCH, 63 (October, 1969), 57-59; William G. Mollenkopf and Donald S. Melville, "A Study of Secondary School Characteristics as Related to Test Scores," RESEARCH BULLETIN 56-6, (Princeton, NJ: Educational Testing Service, 1956).

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[23] C. S. Benson, et al., STATE AND LOCAL FISCAL RELATIONSHIPS IN PUBLIC EDUCATION IN CALIFORNIA, Report of the Senate Fact Finding Committee on Revenue and Taxation, (Sacramento, CA: State Senate of California, 1965).

[24] Dunnell, "Input and Output Analysis of Suburban Elementary School Districts," (paper presented at annual meeting of the American Educational Research Association, New York, New York, February 4-7, 1971).

[25] Bidwell, ADMINISTRATOR'S NOTEBOOK, 3.

[26] Kiesling, REVIEW OF ECONOMIC AND STATISTICS, 356-67.

Several propositions may be drawn from these findings. Economic resources, in all likelihood, contribute to increased school achievement for general student populations. Low socioeconomic status students may not benefit from increased economic resources allocated to schools, either because the economic resources never reach those particular students, or because the human and materials resources purchased by increased financial allocations or the way those resources are mixed to form instructional programs and other services are inappropriate for that segment of the school population. The findings cf Bidwell and Kasarda lend support to this proposition. For them, the variable of economic resources took on significance indirectly through school structural variables affected by economic resources. The prevalent practice in statistical analyses using the stepwise multiple regression procedure of accounting for the effect of school variables after SES variables have been accounted for and concluding on that basis that the effect of schooling is inconsequential has been criticized.[27] When the effects of school variables have been accounted for first, the effect of schooling takes on greater significance. This may explain Dunnell's conclusion that per pupil expenditures were not significant after the effect of socioeconomic status was taken into account.

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[27] Samuel S. Bowles and Henry M. Levin, "More on Multicollinearity and the Effectiveness of Schools," JOURNAL OF HUMAN RESOURCES, 3 (Summer, 1968), 393-400.

Population Attributes: Socioeconomic Characteristics

Several prominent characteristics which represent socioeconomic status of the school community have been identified. Benson, et al., and Dunnell[28] found statistically significant relationships between parents' median years of schooling and student achievement. Benson and others, Grant and Worthington, Dunnell, and Burkhead, et al.[29] found median household income to be a useful predictor of student achievement. Thomas, in a reanalysis of data from the National High School Study, and Burkhead, et al.,[30] using their Atlanta secondary school student sample, found positive correlations between housing conditions and student achievement. Dunnell's[31] study of a sample of fourth graders revealed a positive relationship between the median value of homes and student achievement. Bieker's[32] study of a sample of five rural high schools, however, reported no significant relationship between several family variables and student achievement. Farquhar[33] reported that Dave found a positive correlation between home environment and achievement. Grant and Worthington and Coleman and others[34] reported similar results.

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[28] Benson, et al., FISCAL RELATIONSHIPS; Dunnell, "Input and Output."

[29] Benson, et al., FISCAL RELATIONSHIPS; Claude W. Grant and Lois H. Worthington, "Factors of Academic Success: A Multivariate Analysis," JOURNAL OF EDUCATIONAL RESEARCH, 65 (September, 1971), 7-10; Dunnell, "Input and Output," Burkhead, et al., INPUT AND OUTPUT.

[30] Thomas, "Efficiency in Education: A Study of the Relationship between Selected Inputs and Mean Test Scores in a Sample of Senior High Schools,"(unpublished doctoral dissertation, Stanford University, 1962); Burkhead, et al., INPUT AND OUTPUT.

[31] Dunnell, "Input and Output,"

In a notable study, the Quality Measurement Project, Goodman[35] analyzed a sample of 70,000 seventh and eleventh grade students from 102 New York school districts. He concluded that a significant relationship existed between the occupation of students' parents and student achievement. Coleman, et al., Mayeske and others, Henderson and Long, and Holmes[36] found a statistically significant relationship between home background and achievement. Henderson and Long also found this variable to be a predictor of students' self and social concept.

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[32] Richard F. Bieker, "Social and Economic Determinants of the Educational Achievement of Selected 11th Grade Students in Rural Kentucky," (unpublished doctoral dissertation, University of Kentucky, 1970).

[33] Robin H. Farquhar, "Home Influences on Achievement and Intelligence: An Essay Review," ADMINISTRATOR'S NOTEBOOK, XIII (January, 1965).

[34] Grant and Worthington, JOURNAL OF EDUCATIONAL RESEARCH, 7-10; James S. Coleman, _et al_., EQUALITY OF EDUCATIONAL OPPORTUNITY, (Washington, D.C.: U.S. Office of Education, 1966).

[35] Goodman, SCHOOL QUALITY.

[36] Coleman, _et al_., EDUCATIONAL OPPORTUNITY; G. Mayeske, _et al_., A STUDY OF OUR NATION'S SCHOOLS, (Washington, D.C.: U.S. Office of Education, 1969); Edmund H. Henderson and Barbara H. Long, "Personal-Social Correlates of Academic Success Among Disadvantaged School Beginners," JOURNAL OF SCHOOL PSYCHOLOGY, 9 (1971), 101-113. Mark Holmes, "Prediction of Educational Outcomes from Institutional Variables in a Population of Junior High Schools," (unpublished PH.D. dissertation, University of Chicago, 1969).

Mayeske and others[37] observed that, where the dependence of achievement on the student body's home background was the lowest, school variables made a greater contribution to achievement than did student body variables. He suggested that school variables which contribute to achievement may differ for students from different socioeconomic backgrounds. For this reason, school variables are more highly related to achievement than Coleman and others[38] admitted, and school and non-school variables are very closely related. In any event, it is generally concluded that the influence of family variables on a student's achievement in school is important and must be accounted for in any attempt to partial out the effect of other non-school and school variables.

The influence of group or environmental characteristics, other than those of the student's immediate family, on educational outputs has also been noted. Such characteristics include racial composition of the student's environment and geographical location of the school.

Musgrave, Dunnell, and Levin[39] related the influence of racial composition to student outcomes. For Musgrave, the higher the percentage of blacks in a school district, the lower were the potential earnings of students and the percentage of students going to college. Levin and Dunnell established a relationship between race and academic achievement.

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[37] Mayeske, et al., NATION'S SCHOOLS.

[38] Coleman, et al., EDUCATIONAL OPPORTUNITY.

[39] Frank Webster Musgrave, "The Educational Production Process: A Study of Measures of Quality in New Jersey High School Districts," (unpublished Ph.D. dissertation, Rutgers University, 1968); Dunnell, Input and Output;" Henry M. Levin, FRONTIER FUNCTIONS: AN ECONOMETRIC APPROACH TO THE EVALUATION OF EDUCATIONAL EFFECTIVENESS, (Stanford, CA: Stanford Center for Research and Development in Teaching, Stanford University, 1971).

Grant and Worthington[40] found a statistically significant relationship between the location of the school to a large city and student achievement.

School Inputs

Human and material resources which are received or purchased from the school's external environment comprise the school inputs. Productivity studies have sought to link the influence of these inputs to educational outcomes. The students and staff of an educational system are its human resources. Learning aids, in the form of equipment, materials, and facilities are its material resources.

Human Resources: Student Personnel

It has been documented in the previous section of this review that the external environment in which a student is located influences the level of the student's educational attainment. Research has also sought to predict the level of a student's educational attainment by his and his peers' cognitive capabilities and affective dispositions and relative schooling. The relative influence of the external environment and school inputs on each other is still the subject of much controversy.

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[40] Grant and Worthington, JOURNAL OF EDUCATIONAL RESEARCH, 7-10.

Hanushek and Bieker[41] used measures of cognitive capability to predict achievement. Hanushek's measure was pretest scores on the Stanford Achievement Test. Later success on the same test with 1,061 students in a large California system could be predicted. Likewise, Bieker found statistically significant and positive relationships between mental ability scores and achievement in basic subjects with eleventh grade students in rural Kentucky.

Haller and Butterworth, Guthrie, et al., Coleman, et al., Bowles, Bieker, and Mayeske and others[42] examined affective disposition variables. Haller and Butterworth found a small positive relationship between the influence of one's peers and student achievement, but Coleman and others concluded that the effect of a student's peers on his achievement level is more important than any other school influence. Whereas Haller and Butterworth found no correlation between occupational and educational aspirations and achievement, other studies have been able to link aspirations and academic commitment[43] to achievement. The significantly correlated student variables in Coleman's Equality of Educational Opportunity Study were: 1) aspirations of other students, 2) sense of control over the environment, 3) belief in the responsiveness of the environment, 4) interest in school, and 5) self-concept. Coleman, et al., noted that student body characteristics together accounted for more variation in the achievement of minority group children than did faculty, curriculum, and staff variables collectively. Student body characteristics added about 4 percent to the explanatory power of the regressions for blacks and about 1.5 percent to the explanatory power of the regressions for whites. Mayeske and others used the Coleman data and added student body expectations, attitude toward life, educational plans, and study habits to the list of significant variables. In Michigan, Guthrie and others found that the higher the percentage of students transferring in and out of school each year the lower the achievement level. This was true across all SES levels and with all achievement indicators.

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[41] Eric Hanushek, "The Education of Negroes and Whites," (unpublished Ph.D. dissertation, Massachusetts Institute of Technology, 1968); Bieker, "Social and Economic Determinants."

[42] A. O. Haller and C. E. Butterworth, "Peer Influences on Levels of Occupational and Educational Aspiration," SOCIAL FORCES, 38 (May, 1960), 289-295; J. W. Guthrie, et al., SCHOOLS AND INEQUALITY, (Cambridge, Mass.: MIT Press, 1971); Coleman, et al., EDUCATIONAL OPPORTUNITY; Samuel S. Bowles, EDUCATIONAL PRODUCTION FUNCTION, Final Report to the U.S. Office of Education under Cooperative Research Contract OEC 1-7-00451-265, (Cambridge, Mass.: Harvard University, 1969), Mayeske et al., NATION'S SCHOOLS.

Bowles[44] and Bieker examined the variable of time students devoted to schooling. Bowles found the number of days school was annually in session to be a predictor. Bieker found that the opportunity cost of student time devoted to formal education was positively related to achievement, but the number of job hours worked had a negative effect.

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[43] Bieker, "Social and Economic Determinants."

[44] Samuel S. Bowles, "Toward an Educational Production Function," (paper presented at the Conference on Research in Income and Wealth in November, 1968).

Human Resources: Staff Personnel

Certificated and non-certificated personnel comprise the staff of an educational system. Administrators, teachers, and support personnel comprise the certificated staff. The teacher appears to be the key person in maximizing the learning opportunities for children in the classroom. Coleman and others stated that teacher characteristics accounted for a ". . . higher proportion of variation in student achievement than did all other aspects of the school combined excluding student body characteristics. . .".[45]

The area of teacher effectiveness is concerned with the characteristics of teachers, the teaching process, and their effects upon educational outputs--student attitudes and achievement. Flanders[46] stated that there are aspects of education which may be even more important than achievement per se, such as the desire of pupils to stay in school, to have confidence in their teachers and respect for their skills, and to see themselves as responsible in learning situations.

Stulurow[47] was concerned over inefficient research on teaching, because the basic questions of the teaching process have been avoided.

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[45] Coleman, et al., EDUCATIONAL OPPORTUNITY, p. 316.

[46] Ned Flanders, "Teacher Influence, Pupil Attitudes, and Achievement," in HOW TEACHERS MAKE A DIFFERENCE, (Washington, D.C.: U.S. Office of Education, 1971), p. 113.

[47] Lawrence Stolurow, "Learning Environments--or--Rooms for Thought," in HOW TEACHERS MAKE A DIFFERENCE, (Washington, D.C.: U. S. Office of Education, 1971), p. 155.

He cited, as an example, the fact that trait analysis of teachers as a research question had preempted studies dealing with the instructional strategies of teaching. Studies conducted since Morsh and Wilder's review may have shed some light on discovering those teacher characteristics and teaching processes which maximize traditionally measured outputs. It is difficult, however, to determine teacher effectiveness apart from the influence of students' characteristics and backgrounds. Gage[48] concluded, after a review of the literature, that five global characteristics seem to be components of effective teaching--warmth, cognitive organization, orderliness, indirectness, and problem solving ability.

Researchers have attempted to associate teacher characteristics with student achievement. These characteristics may be grouped according to abilities, attitudes, or teacher-student contact time. Input-output studies traditionally have measured ability by level of educational training and experience, but the possession of competencies required in the teaching process is another component of ability.

Educational training has been measured by the degree level of the teacher,[49] number of teacher graduate credits,[50] percentage of teachers that possess a master's degree,[51] quality of undergraduate institution,[52] level of certification,[53] and educational level of teacher's parents.[54] In all cases, these measures were linked to language arts, mathematics, other subject matter achievement, and attendance. Kiesling[55] found conflicting evidence using degree level and level of certification as predictors of achievement from results obtained in his 1965 study. Hanushek[56] found that neither semester hours of graduate work nor years of experience were related independently to student achievement gains. One of the keys to the teacher's effectiveness appears to be the recency of the teacher's latest educational experience. A teacher who recently has returned to the school after additional training will be more effective in producing student achievement gains. Hanushek further stated that school systems and researchers have been too conscious of measuring formal course credits and degree attainments instead of the teacher's ongoing engagement in expertise-enhancing activities.

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[48] N. L. Gage, ed., HANDBOOK OF RESEARCH ON TEACHING, (Chicago: Rand McNally, 1963(a)).

[49] Coleman, et al., EDUCATIONAL OPPORTUNITY.

[50] Samuel S. Bowles, EDUCATIONAL PRODUCTION FUNCTIONS; Lady Plowden, CHILDREN AND THEIR PRIMARY SCHOOLS, Central Advisory Council on Education, (London: Her Majesty's Stationery Office, 1967).

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[51] M. T. Katzman, "Distribution and Production in a Big City Elementary School System," YALE ECONOMIC ESSAYS, 9 (Spring, 1968), 201-256.

[52] Henry M. Levin, FRONTIER FUNCTIONS.

[53] H. J. Kiesling, THE STUDY OF COST AND QUALITY OF NEW YORK SCHOOL DISTRICTS, Final Report, (Washington, D.C.: Department of Health, Education and Welfare, Office of Education, February, 1970).

[54] Coleman, et al., EDUCATIONAL OPPORTUNITY.

[55] Kiesling, COST AND QUALITY.

[56] E. Hanushek, "The Production of Education, Teacher Quality, and Efficiency," in DO TEACHERS MAKE A DIFFERENCE?, (Washington, D.C.: U.S. Government Printing Office, 1970), p. 92.

White,[57] in a science field study of contrasting patterns of inservice education, found the organization and location of the teacher education programs to be a relevant variable. It appeared that the released-time format of teacher training is effective both in terms of improving subject matter competency and teacher attitude. Previous course work also appeared to be a relevant precondition for increasing competence in subject matter and, to a limited extent, for improving attitude in the field. Previous teaching experience and grade level taught did not appear to be related to subject matter competency but were related to teacher attitude. By examining the relationship between course work and competence and attitude, White related inputs to each other. As conceptualized in this study, only student attainments are outputs. Later in this review, however, competence and attitude are linked to outputs. Thus a causal link between course work and output through teacher competence and positive attitude may be cautiously inferred.

Proxies for educational experience have been positively associated with achievement in several subject matter areas and with student's potential earnings, percentage of students going on to college, holding power (dropout rate), and attendance. Such proxies have included number of years of experience, possession of five or more years of classroom experience, and percentage of tenured teachers. Burkhead, _et al_., Hanushek, Guthrie, _et al_. (with low SES students), Kiesling (with high SES students), Plowden, Flanagan, et al., and Thomas[58] linked number of years of teaching experience with student achievement. Flanagan, _et al_.[59] also linked years of experience to holding power. Katzman and Guthrie, _et al_.[60] found a negative association and no association, respectively. Musgrave[61] found no association between teaching experience and holding power and attendance in New Jersey high schools. Katzman and Flanagan, _et al_., however, found the relationship to be positive. Goodman[62] linked achievement with classroom experience of five or more years Katzman predicted achievement, attendance, and holding power from the percentage of tenured teachers.

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[57] Marjorie A. White, _et al._, "A Study of Contrasting Patterns of Inservice Education," SCIENCE EDUCATION, 53 (February, 1969), 19.

Many persons assume that a teacher becomes more skilled the longer he engages in teaching activities. According to O'Neill and his associates,[63] beyond a given point, age and experience are quite likely to inhibit the capacity to learn and grow on the job. They argued that additional experience increases teacher productivity only for the first six or seven years and has little additional impact on student achievement thereafter. Thus, one would expect the most effective teachers to be those with a few (but not too many) years of experience.

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[58] Burkhead, _et al_., INPUT AND OUTPUT; Hanushek, "Negroes and Whites;" Guthrie, _et al_., SCHOOLS AND INEQUALITY; Kiesling, COST AND QUALITY; Plowden, CHILDREN AND THEIR PRIMARY SCHOOLS; Flanagan, _et al_., AMERICAN SCHOOL; Thomas, "Efficiency in Education."

[59] Flanagan, _et al_., AMERICAN SCHOOL.

[60] Katzman, DISTRIBUTION AND PRODUCTION; Guthrie, _et al_., SCHOOLS AND INEQUALITY.

[61] Musgrave, "Educational Production Process."

[62] Goodman, SCHOOL QUALITY.

Boards of education and teacher associations have negotiated teacher salaries under the basic assumption that the greater the educational degree and experience level, the more effective is the teacher. This philosophy has led to salary schedules that reward teachers for higher degrees and years of experience. Benson, et al., Cohn, Bieker and Flanagan, et al.[64] discovered that such an association does exist using average and median salary as predictors. Kiesling's 1965 study and Musgrave[65] found no association with achievement and holding power and attendance, respectively. Bowles and Levin[66] found a positive association with a twelfth grade white subsample of Coleman data, but a negative correlation with a twelfth grade black subsample. Burkhead, *et al.* linked beginning salary level, Thomas positively associated beginning salary of male teachers, and Kiesling,[67] in his 1958 study positively correlated salary paid the top teacher to academic achievement of students.

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[63] Dave O'Neill, Burton Gray, and Stanley Horowitz, "Educational Equality and Expenditure Equalization Orders: The Case of Hobson v. Hansen," JOURNAL OF HUMAN RESOURCES, 7 (Summer, 1972), 307-325.

[64] Benson, et al., FISCAL RELATIONSHIPS; Elchanan Cohn "Economics of Scale in Iowa High School Operations," JOURNAL OF HUMAN RESOURCES, 3 (Fall, 1968), 422-434; Bieker, "Social and Economic Determinants;" Flanagan, et al., AMERICAN SCHOOL.

[65] Kiesling, COST AND QUALITY; Musgrave, "Educational Production Process."

[66] Bowles and Levin, "More on Multicollinearity," 393-400.

Levin and Michelson's[68] findings based on a single metropolitan area indicated that the wisest resource allocations may be those that purchase able, as distinct from experienced, teachers rather than formal credentials. The problem is determining what characteristics constitute an able teacher and the impact of the program on the teacher. Research findings have indicated that educational training, educational experience, and teacher salary are important determinants of effective teaching. The major point is that the most effective teacher is not necessarily the one with the highest degree, longest experience, and largest salary. These variables are related to teacher effectiveness but the relationship may not be linear.

The effect of certain teacher competencies has been examined.

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[67] Burkhead, *et al.*, INPUT AND OUTPUT; Thomas, "Efficiency in Education;" Kiesling, COST AND QUALITY.

[68] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," JOURNAL OF HUMAN RESOURCES, V (Winter, 1970), 24-33; S. Michelson, "The Association of Teacher Resourceness with Children's Characteristics," in DO TEACHERS MAKE A DIFFERENCE? (Washington, D.C.: U.S. Government Printing Office, 1970), pp. 120-156.

Bowles and Levin, Hanushek, Michelson, Guthrie, et al., and Coleman, et al.[69] found that a teacher's verbal ability has a significant positive impact on student reading achievement. Levin suggested that the utilization of more verbally able teachers could yield four times as much output per dollar as the utilization of additional teacher experience.

Baker[70] took the position that a competent teacher is one skilled in changing his students' behavior in a pre-specified direction. Stevens[71] maintained that more often than not there is a slight positive relation between knowledge of subject and success in teaching, but the relation is by no means consistent and seldom is large. There is a possibility that the relation is more marked at the secondary level than at the elementary level due to the specialization of subject matter at the secondary level.

It is often assumed that new curricular materials will somehow make a teacher more effective. White[72] stated that an ineffective teacher will not suddenly become effective with the adoption of new curriculum materials. Cooper[73] found that there are very few teaching skills that have been related empirically to pupil outcomes.

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[69] Bowles and Levin, "More on Multicollinearity. . .", 393-400; Levin, "A Cost-Effectiveness Analysis. . ."; Hanushek, "Negroes and Whites. . .;" Michelson, DO TEACHERS MAKE A DIFFERENCE?; Guthrie, et al., SCHOOLS AND INEQUALITY; Coleman, et al., EDUCATIONAL OPPORTUNITY.

[70] Eva L. Baker, "Relationship Between Learner Achievement and Instructional Principles Stressed During Teacher Preparation," JOURNAL OF EDUCATIONAL RESEARCH, 63 (November, 1969), 99-102.

[71] J. M. Stephens, THE PROCESS OF SCHOOLING--A PSYCHOLOGICAL EXAMINATION, (New York: Holt, Rinehart and Winston, 1967).

[72] White, et al., SCIENCE EDUCATION, p. 13.

Mayeske, _et al._[74] stated that, although teachers of black students may not appear to differ appreciably from those of white students on many formal resource measures, they do differ in their actual abilities and attitudes toward students. This view is based on the low associations found between teacher verbal ability and sex, age, training, experience, salary, credits beyond highest degree, and localism of career. They further stated that, when school systems allocate more money for experience and highly trained teachers, it seems that they are not purchasing higher ability. This conflicts with Levin's[75] findings that teacher experience appears to be nearly twice as effective per dollar of expenditure for Negro students as it is for whites.

Teacher attitude is viewed as an important predictor of achievement by several researchers. Guthrie, _et al._[76] used "satisfaction with teaching "perception of compatibility of his or her faculty members," and Guthrie, et al., and Levin[77] used "satisfaction with a particular school" as predictors. Burkhead, et al. and Katzman[78] found an inverse relationship between teacher turnover rate and achievement. Burkhead, et al., found that low rates of teacher turnover in the Atlanta schools associated positively with pupil test scores of verbal ability. Katzman reported that a high turnover rate among teachers within attendance districts in Boston had a slight negative association with holding power, attendance and achievement. Stephens[79] clearly implied that teachers will count in some way with pupils in that the teacher must be taken seriously--loved, admired, or feared. Beckman[80] observed that, when teacher and child react in the classroom, the pattern of the child's performance and the teacher's sentiments toward him are related.

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[73] James Cooper, Howard Jones, and Wilford Weber, "Specifying Teacher Competencies," JOURNAL OF TEACHER EDUCATION, 24 (Spring, 1973), 17-23.

[74] Mayeske, et al., NATION'S SCHOOLS.

[75] Levin, JOURNAL OF HUMAN RESOURCES, 31-33.

[76] Guthrie, et al., SCHOOLS AND INEQUALITY.

Researchers have examined the relationship between student outcomes and teacher or other personnel contact time with students. Such contact time is inferred by using the following as proxies: 1) number of students, 2) the relationship between number of students and number of teachers, and 3) number of and ratio of administrative and support personnel to students. The findings of the studies are inconclusive with respect to class size. Several studies[81] found an inverse relationship between class size and student outcomes. Yet other studies[82] found no relationship. Averch and Kiesling[83] found small class sizes to be positively associated with the achievement of ninth graders. Guthrie and his associates[83] reported that as the number of students attending a s school increases, the achievement test scores at all SES levels on all tests decrease. Of those[85] who have examined pupil-teacher ratio, Burkhead, _et al_., using teacher man-years per student, found no association, but other researchers[86] found an inverse relationship.

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[77] Levin, FRONTIER FUNCTIONS.

[78] Burkhead, et al., INPUT AND OUTPUT; Katzman, YALE ECONOMIC ESSAYS, 201-256.

[79] J. M. Stephens, THE PROCESS OF SCHOOLING--A PSYCHOLOGICAL EXAMINATION.

[80] Linda Beckman, "Effects of Students' Performance on Teachers' and Observers' Attributions of Causality," JOURNAL OF EDUCATIONAL PSYCHOLOGY, 61 (February, 1970), 76-82.

Dunnell and Mollenkopf and Melville[87] found that the number of staff-specialists in the school and class size were related significantly to aptitude and achievement test scores. Kiesling[88] found no relationship between pupil achievement and the ratio of principal and supervisors to pupils or principal and assistant principal per 1000 students. Of all the resources Kiesling examined in his 1965 study, those devoted to central administration and supervision were the school inputs most consistently related to pupil achievement. Likewise, Benson and others[89] associated administrative salary level and academic achievement in populous California school districts with pupil achievement.

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[81] Mollenkopf and Melville, RESEARCH BULLETIN; Dunnell, "Input and Output;" Bowles, EDUCATIONAL PRODUCTION FUNCTIONS.

[82] Kiesling, COST AND QUALITY; Flanagan, _et al_., AMERICAN SCHOOL; Bieker, "Social and Economic Determinants;" Burkhead, _et al_., INPUT AND OUTPUT.

[83] H. Averch and H. J. Kiesling, "The Relationship of School and Environment to Student Performance: Some Simultaneous Models for the Project Talent High Schools" (Unpublished manuscript, Santa Monica, Ca.: Rand, 1970).

[84] Guthrie, _et al_., SCHOOLS AND INEQUALITY.

[85] Burkhead, INPUT AND OUTPUT.

[86] Kiesling, COST AND QUALITY; Mollenkopf and Melville, RESEARCH BULLETIN; Katzman, YALE ECONOMIC ESSAYS, 201-256.

[87] Dunnell, "Input and Output;" Mollenkopf and Melville, RESEARCH BULLETIN.

Material Resources: Learning Aids

Material resources consist of the physical supplies and equipment purchased for use in the system. Bieker[90] found no relationship between total investment in equipment and student achievement in Kentucky high schools. Kiesling,[91] on the other hand, reported conflicting results, that is, positive and zero correlations, from two studies on fifth and eighth grade students in New York state. Both Thomas and Flanagan and others,[92] using subsamples of Project Talent's national data, noted a positive correlation between the number of volumes in the school library and student achievement. In addition, Flanagan and his associates linked volumes in the school library to the school's holding power and the percent of males from the previous year's class who went to college. In related research, Guthrie[93] and others, using Michigan data from the Equality of Educational Opportunity Study, were able to associate the number of library volumes per 1000 students with student achievement, but found no relationship between the supply of textbooks and student achievement. Musgrave,[94] in a study of New Jersey school districts, found a positive relationship between per pupil investment in library and audio-visul equipment and student output measures.

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[88] Kiesling, COST AND QUALITY.

[89] Benson, FISCAL RELATIONSHIPS.

[90] Bieker, "Social and Economic Determinants."

[91] Kiesling, COST AND QUALITY.

[92] Thomas, "Efficiency in Education;" Flanagan, et al., AMERICAN SCHOOL.

Material Resources: Facilities

The largest single material resource input is the cost of constructing and maintaining school facilities. Several research projects have explored the notion that particular characteristics of these facilities may affect a child's learning. The characteristics examined include financial investment in and size, condition, presence, age and utilization of facilities.

Bieker[95] found no significant correlation between "total investment in plant and facilities" and student achievement. Kiesling,[96] using data from his 1965 sample, also found no significant relationship between these variables, although a significant relationship was reported in his 1958 sample.

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[93] Guthrie, et al., SCHOOLS AND INEQUALITY.

[94] Musgrave, "Educational Production Process.

[95] Bieker, "Social and Economic Determinants."

Guthrie[97] and his associates examined school site size as a predictor of language arts and mathematics achievement, but found generally no relationship among Michigan students. Among students in the upper half of all SES deciles in that particular sample, however, those two variables associated positively. Katzman[98] examined "non-crowding" as a predictor of student achievement in a sample of Boston elementary schools. "Non-crowding" was associated with increments of reading achievement. Crowding was derived from the number of classrooms which contained more than 35 students. Students in excess of this number were taken to be in some sort of makeshift arrangement. Guthrie[99] and others found the number of "classrooms per one thousand students" and the "percentage of makeshift classrooms" to be correlated positively and negatively, respectively, with pupil achievement across all SES deciles in his student sample.

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[96] Kiesling, COST AND QUALITY.

[97] Guthrie, _et al_., SCHOOLS AND INEQUALITY.

[98] Katzman, YALE ECONOMIC ESSAYS, 201-256.

[99] Guthrie, _et al_., SCHOOLS AND INEQUALITY.

Bowles and Levin,[100] in a re-analysis of the Coleman data, observed a significant positive association between the presence of science laboratory facilities and the achievement of twelfth grade black students. Yet, when the data for both black and white students were aggregated, no meaningful relationship was found.

Plowden, Bowles, and Guthrie, et al.,[101] reported inverse relationships between the age of the school building and student achievement, but Flanagan[102] found no relationship between the age of the school building and holding power and student achievement. Burkhead, Fox, and Holland,[103] in a study of eleventh graders from Chicago and small communities using data from Project Talent, found no significant relationship between school building age and the achievement of eleventh grade Chicago students, whereas they reported a negative relationship between these variables with students from small communities. Kiesling[104] reported that a facility's "intensity of use" was a predictor of student achievement with a sample of fifth and eighth graders in New York State.

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[100] Bowles and Levin, JOURNAL OF HUMAN RESOURCES, 393-400.

[101] Plowden, CHILDREN AND THEIR PRIMARY SCHOOLS; Bowles, EDUCATIONAL PRODUCTION FUNCTIONS; Guthrie, et al., SCHOOLS AND INEQUALITY.

[102] Flanagan, et al., AMERICAN SCHOOL.

[103] Burkhead, et al., INPUT AND OUTPUT.

[104] Kiesling, COST AND QUALITY.

Attributes of an Input (Resource) Mix Treated as School Input

In the conceptual framework used as the basis for the development of a cost-effectiveness/productivity analytical model in this thesis (which will be described in Chapter IV), curricular variables are considered an integral part of the input (resource) mix. The input (resource) mix consists of school (resource) inputs translated into school programs. These inputs include, among other things, curricular content and process requirements specified in a program description or characteristics observed during a program's operation. Rather than examining the impact on learning of a total program, program components or curricular variables may be treated as if each were an input and subjected to an input-output analysis mode of examination.

Quilling[105] proposed that several instructional process and content characteristic variables could be included in a regression equation to examine the effect of each variable on student outcomes as traditionally measured by multiple regression analysis. After an initial screening, three of the four variables included in the regression equation predicted the attainment of intellectual skills in reading and mathematics. They were curricular decision unit size, rate adaptiveness, and instructional granularity of the content.

The use of student ability grouping for instruction has been the subject of much controversy. The results of several studies indicated that "ability grouping of students," a curricular characteristic examined as an input variable, either influenced achievement negatively or demonstrated no influence whatsoever. Using Project Talent data, Bowles[106] found that ability grouping negatively influenced reading and math achievement among twelfth grade black students. Ekstrom,[107] in a review of thirty investigations of the effectiveness of homogeneous grouping, found no identifiable advantage or disadvantage in the procedure.

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[105] Quilling, "A Data Analysis Approach." Refer to page 103 for the definition of the instructional process and content variables.

"Time" as an Aggregate Input Characteristic

Several researchers have sought to explain the impact of several environmental, school, and input mix variables collectively through the concept of "time". Wiley and Harnischfeger[108] examined the relationship between "exposure to schooling," expressed as the average number of hours of schooling per year in a particular school, and verbal, reading, and mathematics achievement. Using a school-level regression analysis which adjusted for pupils' prior background characteristics (race, number of children living in the child's home), the researchers concluded that

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[106] Bowles, EDUCATIONAL PRODUCTION FUNCTIONS.

[107] Ruth B. Ekstrom, "Experimental Studies of Homogeneous Grouping: A Critical Review," SCHOOL REVIEW, 69 (Summer, 1961), 216-223.

[108] Wiley and Harnischfeger, EDUCATIONAL RESEARCHER, 7-12.

> . . . in schools where students receive 24 percent more schooling, they will increase their average gain in reading comprehension by two-thirds and their gains in mathematics and verbal skills by more than one third.[109]

Therefore, the amount of schooling a student receives is a highly relevant predictor of achievement. Wiley and Harnischfeger's Individual Instructional Exposure and Achievement Model (See Figure 3.9) expands upon their initial concept of "time" represented in Figure 3.8 and examines time in a broader context. "Total active learning time," as the dependent variable, is a combination of several measured pupil, teacher, school, and curricular variables. Thus it represents more than simply specified or operationalized program characteristics.

Some recent findings on time and learning reported by Bloom[110] have rekindled his interest in the subject. Studies of "elapsed time" record the amount of time consumed when a student presumably is working on learning tasks. To Bloom, time is a more complex concept than is embodied in recent literature on the topic. Bloom proposes to deal with "time on task," which conceptually includes both overt and covert student activities. "Time on task" is a function of

> . . . the student's achievement over the preceding units of the the course [cognitive entry behaviors], by his interest in the subject [affective entry characteristics], and by the quality

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[109] Ibid., 9.

[110] Benjamin S. Bloom, "Time and Learning," AMERICAN PSYCHOLOGIST, (September, 1974), 682-688.

> of instruction provided.[111]

To substantiate his claim, he reported high correlations between these three variables and time on task (.75) and achievement (.85 or higher). By defining the concept in this manner, he recognized human differences in learning and characteristics which enhance one's learning how to learn more effectively. The differences in time on task are complex and probably include

> . . . cultural differences, the importance of school learning to the students and their parents, the ways in which teachers use the time available for learning, the quality of the instruction, and the extent to which students attain the prerequisites for a particular learning task.[112]

Bloom related different achievement levels obtained between mastery learning processes and conventional programs to differences in the amount of time students actively engaged in the learning process.

Summary

Several graphic and mathematical models of productivity exist in the literature to conceptualize the relationship between environmental inputs to an educational system, the inputs of that system, and its outputs. These models can be classified according to the cause-effect relationship on learning which each depicts, that is, whether the relationships are viewed as additive, open systems, or interactive.

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[111] _Ibid._, 686.

[112] _Ibid._, 687.

The production function model mathematically demonstrates the relationship of school and non-school inputs to student outcomes. It is a mathematical depiction of the additive model, wherein environmental and school influences are viewed linearly, as separate but additive. Multiple regression analysis is the statistical technique used to estimate the contribution to output of each input or group of inputs relative to other input(s).

The simultaneous equation model consists of a set of linear production function equations. In the model there exists an equation for each cognitive and affective outcome examined. Simultaneity is present, since one variable viewed as an output in one equation may also be perceived as an input in other equations. This simultaneity is seen as representative of the interactive model, wherein the environment and the school affect each other and each other's impact on outputs.

In the open systems model the environment is viewed as affecting the nature of both school effects and outputs. The statistical technique of path analysis has been used to examine the direct effects of environmental inputs on outcomes and the indirect effects of environmental inputs on the same outcomes, through the influence of system inputs.

Productivity models have been proposed to serve specific research purposes. These models display specific environmental, school and output components and their relationships for the purpose of determining the existence, strength, and direction of relationships. The results of such research efforts serve as critical evaluations of those models.

Models have been proposed which view certain curricular variables as inputs rather than as process characteristics, for the purpose of using statistical analysis techniques which are appropriate for the input-output mode of analysis. Curricular variables characterize the manner in which school resources are mixed or transformed into programs and, thus, describe the educational process. By labelling each curricular characteristic as an input, it can be subjected to statistical analysis to determine whether and to what extent it is associated with learning outcomes.

The concept of "time" as an input has been used to represent several environmental, system input, and process variables in combination. In such cases, the "time one is exposed to learning" or is "on learning task" is a condition of the learner's background, cognitive ability, and attitudes, the teacher's quality, and the curriculum utilized. Unfortunately, aggregating several inputs into one, which represents all of them, does not allow for the critical evaluation of each input's or system component's value in the overall learning process.

The use of input-output analysis in education carries with it methodological problems which limit the definitiveness of the results. The problems may be linked to the natural setting of educational systems, multicollinearity measures of independent variables, limited and narrow measures of outcome, and the practice of data aggregation.

Many studies of educational productivity have been conducted to determine whether, to what extent, and in what ways environmental and school inputs affect student outcomes. External environmental inputs are represented by economic resources made available to the system and socioeconomic characteristics of the population served by the system. School inputs are the human and material resources used by the system. Students and staff represent human resources; learning aids, in the form of materials and equipment, and facilities represent material resources. The quantity and quality of these resources are represented by proxy variables in multiple regression equations.

It is generally agreed that the influence on a child's learning exerted by his home background (represented by socioeconomic characteristics) is generally the strongest predictor of student achievement. To a lesser extent, but also highly significant, are peer cognitive and affective influences. Although there are conflicting results as to the statistical significance of various inputs, most studies report statistically significant associations. A major controversy involves the extent to which school characteristics influence student output. Some have argued that what the school does with a child accounts for little of the variation in output. Others have argued that the way in which variables are treated in the statistical analysis can measurably alter the results obtained. Different results have been reported with different student racial and SES groups, but no consistent patterns are observed.

The proxy variables that have been used predominantly to represent various inputs and have been generally found to be statistically significant predictors of output are listed as follows:

Input Variable Categories	Proxy Variables
Economic Resources	per pupil expenditure
Population Attributes: Socioeconomic Characteristics	parents' level of schooling parents' income parents' occupation housing conditions racial composition
Human Resources: Student Personnel	
self and peer's cognitive capabilities	mental ability prior achievement
self and peers' affective dispositions	occupational aspirations educational aspirations interest in school self-concept student body school transfers
relative schooling	student time investment in formal education number of outside job hours
Human Resources: Staff Personnel	
abilities	level of educational training amount of educational experience salary verbal ability
attitudes	satisfaction with one's teaching, peers' teaching abilities, and school situation teacher turnover rate
contact time with students	pupil-teacher ratio staff specialists
Material Resources: Learning Aids	ratio of number of or monetary investment in library volumes per pupil

Material Resources: Facilities

age of school building
student crowding
intensity of use

Attributes of an Input (Resource) Mix Treated as School Inputs

heterogeneous versus homogeneous student ability grouping

Time as an Aggregate Input Characteristic

time on task
instructional exposure time

The following output measures predominantly have been used:

(1) language arts and/or reading achievement;

(2) mathematics achievement;

(3) general subject matter achievement;

(4) holding power; dropout rate;

(5) attendance;

(6) potential income of students;

(7) college academic performance; and

(8) percentage of students attending college.

Any effort to determine the effectiveness of educational programs must be able to control for or hold constant other influences on student outputs. To do so requires the identification and utilization of those potentially influential sources. It is recognized that the quality (validity) of a research design, that is, the degree to which alternative sources of variation are controlled, may significantly alter research findings. This chapter, however, has served to identify and classify several potential sources of influence over student outputs which are extraneous to the educational program and which must be controlled in multivariate statistical analyses.

CHAPTER IV

STATEMENT OF THE PROBLEM AND DESIGN OF THE STUDY

This chapter is concerned with the identification of the research problem investigated in the present study and with a presentation of the design of the study.

Statement of the Problem

In specifying the problem statement, the program of Individually Guided Education developed at the Wisconsin Research and Development Center for Cognitive Learning at the University of Wisconsin-Madison is an important consideration. This study, which was supported by the Center, was justified on the basis of an anlysis of the status of cost-effectiveness and productivity in education as revealed by the literature on these two topics reviewed in Chapters II and III, respectively.

Objectives of the Wisconsin Research and Development Center for Cognitive Learning

The Wisconsin Research and Development Center for Cognitive Learning at the University of Wisconsin-Madison has initiated research designed to assess the impact that the Center's system of Individually Guided Education (IGE) or its individual components, for example, the Multiunit Elementary School (MUS-E), has upon student cognitive achievement and affective development. The Center developed this system which has been implemented in over 2,000 elementary schools across the United States.

Several components of the IGE system are either in varying stages of development and implementation or are being planned for development. They include:

(1) a new organization for instruction and related administrative arrangements;

(2) a model of instructional programming for the individual student;

(3) curriculum components in prereading, reading, mathematics, motivation, and environmental education;

(4) other curriculum components;

(5) a system for managing instruction by computer; and

(6) instructional strategies.[1]

Plans call for "continuing programmatic research . . . to provide a sound knowledge base for the components under development and for improved second generation components." Consequently, the primary objective is "to provide the resources to develop IGE as an effective, robust, and comprehensive instructional system which is a realistic alternative to the conventional age-graded elementary and secondary program."[2]

One of the Center's research units is charged with responsibility for determining

> the effect of several significant organizational/administrative elements and parameters on operation in a multiunit school, and in some instances to develop prototypic models and/or procedures

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[1] Richard A. Rossmiller, RESOURCE ALLOCATION AND MANAGEMENT PLAN: THE WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING, (Madison, WI: Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin-Madison, 1973), p. C-2.

[2] Ibid.

> to help insure proper functioning of these elements in the IGE environment.[3]

One aspect of the above task is an evaluation of the effectiveness and/or productivity, in the economic sense, of IGE and its various components. In planning to accomplish this assignment, several milestones were identified and the tasks associated with each milestone were described. Those tasks were:

(1) a review of the literature relative to cost-effectiveness to include cost-effectiveness analysis, cost-benefit analysis, input-output analysis, and teacher effectiveness and to ascertain the state of the art and the models which have been employed in this type of research;

(2) the development of a prototypic cost-effectiveness model incorporating indicators of human and material resource inputs and cognitive and affective outputs; and

(3) the refinement of the cost-effectiveness model through the use of initial case studies and subsequent large scale field tryouts.

The model should provide practitioners with a methodology which can be employed to evaluate the productivity of IGE and other alternatives and to provide feedback from the field to IGE designers, implementors, and evaluators.

Purpose of the Study

It was a purpose of this study to 1) review the literature relative to cost-effectiveness in order to ascertain the state of the art and to identify models which have been employed in research on productivity and 2) develop a prototypic cost-effectiveness model incorporating indicators of human and material resource input and cognitive and affective output. The prototype will be tested and refined subsequent to this research endeavor.

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[3] *Ibid*., p. D-16.

Chapters I through III presented a review of the literature on cost-effectiveness analysis, cost-benefit analysis, input-output analysis, and teacher effectiveness as a precondition to the development of a cost-effectiveness model. Chapter I discussed the economic and systems framework within which cost-effectiveness operates as a technique for analyzing returns from educational systems. The techniques of input-output, cost-benefit, and cost-effectiveness analysis were introduced. It was shown that cost-benefit analysis generally operates at the macroanalysis level, a level which considers only gross categorizations, i.e., number of years of schooling, to compare the difference between the present value of benefits and costs in monetary terms. This technique provides for a comparison of the internal rate-of-return from education with the return from other public activities, or for comparisons between large systems within the educational sector, i.e., early childhood education or vocational education, to make public investment decisions.

Cost-effectiveness analysis, on the other hand, operates at a microanalysis level where the output measure is very difficult to quantify monetarily, but can be quantified according to an attained performance level. Thus, cost-effectiveness is a more appropriate economic technique with which to compare the productivity of educational programs or processes and their component parts. Input-output analysis also has been employed at the microanalysis level to compare the relative effects of quantitative changes in a single resource on output levels. This technique has been extended for use in cost-effectiveness analyses. As a result of input-output analysis, the impact of certain inputs has been compared with their unit cost thus providing a cost-effectiveness value for each unit. For this reason it was given further consideration in Chapter III.

Chapter II reviewed the state of the art and the models which have been employed in or proposed for use in cost-effectiveness investigations. Much of the literature on cost-effectiveness analysis focuses on its application to military systems and engineering projects. Recently, however, educational systems have designed and/or utilized cost-effectiveness techniques to evaluate:

(1) performance contracted programs;[4]

(2) programs for disadvantaged children funded under Title I of the Elementary and Secondary Education Act;[5]

(3) vocational education;[6]

(4) characteristics of teacher quality;[7]

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[4] Charles Blaschke, et al., "Performance Contract-Turnkey Approach to Urban School System Reform," EDUCATIONAL TECHNOLOGY, X (September, (1970), 47.

[5] Clark C. Abt, DESIGN FOR AN EDUCATION SYSTEM COST-EFFECTIVENESS MODEL, (Cambridge, MA: Abt Associates, 1967), p. 4.

[6] Teh-wei Hu, et al., A COST-EFFECTIVENESS STUDY OF VOCATIONAL EDUCATION, (University Park, PA: Institute for Research on Human Resources, Pennsylvania State University, 1969).

[7] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," JOURNAL OF HUMAN RESOURCES, V (Winter, 1970), 24-33.

(5) curricular materials;[8]

(6) day care delivery systems;[9]

(7) computer assisted instruction;[10]

(8) college level courses;[11] and

(9) elementary and secondary school reading programs.[12]

The techniques may be classified according to the analytical methodology which was employed. The models and studies reviewed in Chapter II were arranged accordingly, since the development of methodology is the focus of this study. Several typologies of cost-effectiveness methods exist in the literature. One classified models according to the mathematical approach used to integrate cost and effectiveness values;[13]

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[8] Clark C. Abt, "How to Compare Curriculum Materials," NATION'S SCHOOLS, 86 (July, 1970), 21-28.

[9] Dennis J. Deloria, *et al.*, A DESIGN FOR A NATIONAL DAY CARE COST-EFFECTIVENESS EXPERIMENT, FINAL REPORT, (Ypsilanti, MI: High/Scope Educational Research Foundation, 1972).

[10] Dean Jamison, *et al.*, "Estimated Costs of Computer Assisted Instruction for Compensatory Education in Urban Areas," EDUCATIONAL TECHNOLOGY, X (September, 1970), 49-57.

[11] Philip Leslie Doughty, "Effectiveness, Cost and Feasibility Analysis of Course in College Level Geology," (unpublished Ph.D. dissertation, Florida State University, 1972).

[12] Joan Marie Webster, A COST-EFFECTIVE ANALYSIS OF SELECTED READING PROGRAMS IN GRAND RAPIDS PUBLIC SCHOOLS, ED 063583, (Washington, D.C.: Educational Resources Information Center, 1972).

[13] Karl Seiler, III, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, (New York: Wiley-Interscience, 1969), pp. 71-101.

another classified models according to whether or not external, financial, and student resources and manipulatable characteristics are to be considered in the evaluation and, if they are considered, whether they are treated as control variables or predictor variables. The result is three areas of educational system cost-effectiveness evaluations--alternative instructional programs, total institutional programs, or input utilization options.[14] The model portrayed to illustrate the three alternatives is a basic conceptual framework of education subject to cost-effectiveness analysis. This basic conceptual framework has been applied in a design to illustrate those components of one type of instructional intervention.[15] These models, however, do not demonstrate the analytical process within cost-effectiveness; they illustrate the components of an educational system under study.

Models exist which place cost and effectiveness dimensions in perspective within the broader systems analysis process.[16] Several procedural models of cost-effectiveness exist. At least two of them broadly interpret the function of cost-effectiveness to include the generation of objectives and alternatives to reach those objectives,[17] rather than simply the analysis and integration of the cost and effectiveness of competing alternatives. One of them requires the prediction of cost and effectiveness values and the implementation of the most cost-effective alternative.[18] One lacks a feedback link.[19] Noticeably absent from all of the models which were reviewed was an illustration of what is required to estimate cost and effectiveness measures, i.e., the components of the cost and effectiveness dimensions and their interrelationships.[20] One model did, however, detail the components of the cost dimension.[21] To a great extent, these procedural models were not based on a theoretical framework of an educational system which identified the interrelationship of data elements in the educational system.

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[14] Marvin C. Alkin, "Evaluating the Cost-Effectiveness of Instructional Programs," (from the proceedings of the Symposium on Problems in the Evaluation of Instruction, Center for the Study of Evaluation, University of California, Los Angeles, 1967), pp. 20-30.

[15] Clark C. Abt, DESIGN FOR AN EDUCATION SYSTEM COST-EFFECTIVENESS MODEL, p. 4.

[16] S. A. Haggart and M. B. Carpenter, "Program Budgeting As An Analytical Tool for School District Planning" (Santa Monica, CA: Rand, no date), p. 2.

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[17] Francis G. Cary, "Development of An Instructional Cost-Effectiveness Analysis Model for Use in School Districts,"(unpublished Ed.D. dissertation, State University of New York at Buffalo, 1972), p. 109; Ned Broward Lovell, "Cost-Effectiveness Design (K-12),"(unpublished Ph.D. dissertation, Florida State University, 1971), p. 79.

[18] Cary, "Instructional Cost-Effectiveness for School Districts," p. 109.

[19] Donald Covel Burgett, "The Development of a Procedural Model for Making Effectiveness/Cost Evaluations of Occupational Education,"(unpublished Ph.D. dissertation, Cornell University, 1970).

[20] Ibid., p. 36; Doughty, "Effectiveness, Cost and Feasibility Analysis;" Cary, "Instructional Cost-Effectiveness for School Districts," p. 109; Lovell, "Cost Effectiveness Evaluation," p. 79.

[21] Charles Blaschke, et al., "Performance Contract-Turnkey Approach to Urban School System Reform," EDUCATIONAL TECHNOLOGY, X (September, 1970), 47.

Several cost-effectiveness studies have been conducted. One examined the cost-effectiveness of input (not program) utilization options.[22] Others compared the cost-effectiveness of instructional programs using experimental design approaches;[23] and another compared the cost-effectiveness of different components or processes within a single program structure using a panel of judges to determine the utility of each component or process.[24]

One researcher recently recommended further research needs after he examined the status of cost-effectiveness:

(1) More instructional designers with cost-effectiveness expertise should disseminate their experiences.

(2) An analytical model for instructional cost-effectiveness that could be easily modified for differing applications is needed.

(3) Research on the direct application of instructional cost-effectiveness is almost non-existent.[25]

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[22] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," JOURNAL OF HUMAN RESOURCES, V (Winter, 1970), 24-33.

[23] Dean Jamison, et al., EDUCATIONAL TECHNOLOGY, 49-57; Joan Marie Webster, COST-EFFECTIVE ANALYSIS OF SELECTED READING PROGRAMS.

[24] William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corporation, Association of School Business Officials, 1971), pp. 241-265.

[25] Robert Hardy Pearson, "A Study of Cost-Effectiveness Analysis with Implication for Instructional Decision-Making,"(unpublished Ph.D. dissertation, Syracuse University, 1972), pp. 163-164.

Hartley[26] also identified several research needs:

(1) PPB system research and application are needed at the local level in order to determine the best possible features to adopt.

(2) Advances are needed in the systematic consideration of alternatives.

(3) New instructional methodologies should be subjected to intensive research.

(4) Research is needed in the broad area of the economics of education which utilize techniques requiring quantitative measures.

The need for the development of a cost-effectiveness model has been documented. The model shall meet the following requirements:

(1) demonstrates the analytical process, that is, the dynamic interaction of components between and within the cost and effectiveness dimensions, the integration of cost and effectiveness, and feedback;

(2) incorporates indicators of human and material resource inputs and cognitive and affective outputs and provides for an examination of resource configurations;

(3) is applicable to de facto comparisons of operationalized educational programs in the natural school setting, since school settings are not amenable to experimental treatments nor are such treatments condoned by the public; and

(4) narrowly interprets the analytical boundary of cost-effectiveness, whereby it is assumed that educational objectives have been devised and alternatives to accomplish those objectives have been selected for the analysis.

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[26] Harry J. Hartley, EDUCATIONAL PLANNING-PROGRAMMING-BUDGETING, A SYSTEM APPROACH,(Englewood Cliffs, NJ: Prentice-Hall, 1968), pp. 247-250.

Definition of Cost-Effectiveness Analysis

For the purposes of this study, cost-effectiveness analysis is defined as:

> an economic and systems evaluation technique for comparing the productivity of pre-selected competing alternatives established for accomplishing some desired end, whereby the resource consumption and output, attributable only to each alternative, are integrated into a common decision framework.

Design of the Study

The study's design adopts a theoretical model of formal education as a system which may be subjected to economic analysis. The design also specifies the criteria which the cost-effectiveness/productivity analytical model must meet and formulates a plan for the model's development, including the expected product. It also specifies criteria for the evaluation of the model.

A Theoretical Framework for the Cost-Effectiveness/Productivity Analytical Model

Rossmiller, Marinelli, and Geske[27] have developed a conceptual framework of the education production process for the purpose of conducting economic analyses in education (see Figure 4.1). The following is a brief explication of that conceptual framework.

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[27] Richard A. Rossmiller, Joseph J. Marinelli, and Terry G. Geske, ECONOMIC ANALYSIS OF EDUCATION: A CONCEPTUAL FRAMEWORK, Theoretical Paper, (Madison, WI: Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin-Madison, 1975).

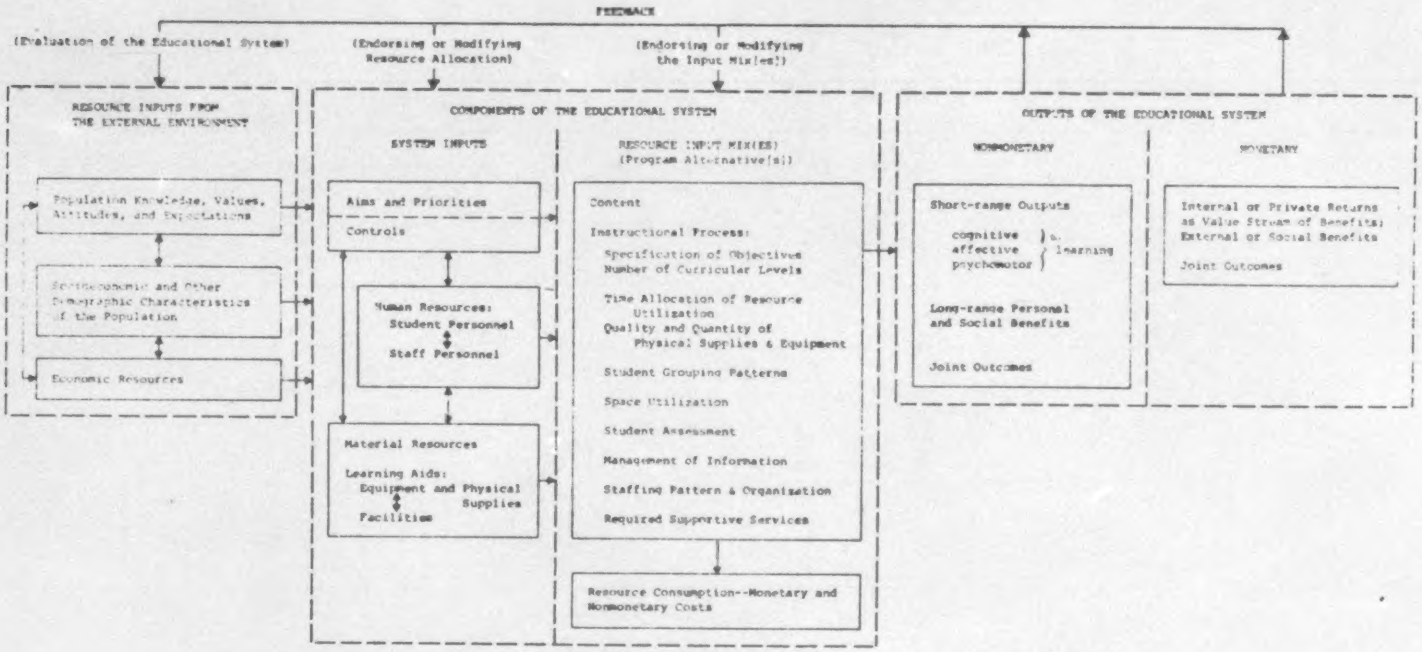
FEEDBACK
(Evaluation of the Educational System)
(Endorsing or Modifying Resource Allocation)
(Endorsing or Modifying the Input Mix[es])
RESOURCE INPUTS FROM THE EXTERNAL ENVIRONMENT
Population Knowledge, Values, Attitudes, and Expectations
Socioeconomic and Other Demographic Characteristics of the Population
Economic Resources
COMPONENTS OF THE EDUCATIONAL SYSTEM
SYSTEM INPUTS
Aims and Priorities
Controls
Human Resources:
Student Personnel
Staff Personnel
Material Resources
Learning Aids:
Equipment and Physical Supplies
Facilities
RESOURCE INPUT MIX(ES)
(Program Alternative[s])
Content
Instructional Process:
Specification of Objectives
Number of Curricular Levels
Time Allocation of Resource Utilization
Quality and Quantity of Physical Supplies & Equipment
Student Grouping Patterns
Space Utilization
Student Assessment
Management of Information
Staffing Pattern & Organization
Required Supportive Services
Resource Consumption--Monetary and Nonmonetary Costs
OUTPUTS OF THE EDUCATIONAL SYSTEM
NONMONETARY
Short-range Outputs
cognitive
affective
psychomotor
s.
learning
Long-range Personal and Social Benefits
Joint Outcomes
MONETARY
Internal or Private Returns as Value Stream of Benefits;
External or Social Benefits
Joint Outcomes

Figure 4.1--A Conceptual Framework of Education Subject to Economic Analysis

Source: Richard A. Rossmiller, Joseph J. Marinelli, and Terry G. Geske, ECONOMIC ANALYSIS OF EDUCATION: A CONCEPTUAL FRAMEWORK. Theoretical Paper (Madison, WI: Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin-Madison, 1975).

Resource Inputs to the Educational System from the External Environment

Resource inputs to the educational system from the external environment may be classified as to: (1) the knowledge, values, and attitudes of the population and the expectations held by that population for the educational system, (2) socioeconomic and demographic characteristics of that population, and (3) the economic resources made available to the system. Population characteristics influence the nature of educational aims and content and the attributes and quantity of students and staff of the system. Economic resources made available to the system (generally through taxation) are used to purchase the human and material resources needed to operate educational programs. The level of resources made available will depend to a large extent upon the ability and willingness of the external environment to furnish economic resources to the system.

Components of the Educational System

The educational system proper consists of two components: (1) inputs to the school and (2) the manner in which those inputs are combined into programs and services.

Inputs to the System.--The system has three sets of inputs with which to work: material resources, human resources, and the aims, priorities and controls which have been established for and by the system. Material resources consist of the physical supplies and equipment purchased for use in the system and the facilities which house the system. Material resources, i.e., learning aids are utilized by pupils and teachers in the education process. Human resources fall into two major categories--the students who attend the system and the school staff.

The background and characteristics of pupils will significantly affect learning activities and objectives. Personnel within the system include teachers, librarians, administrators, guidance specialists, bus drivers, cooks, and other support personnel who are needed to maintain and operate the resources of the system. The characteristics of the staff members will have a measurable effect on the systems output.

A final school resource input consists of the aims, priorities, and controls established for and by the system. Expectations are established for the system by the environment external to that system. They may take form of written mandates or simply may be imbedded in the unwritten values and attitudes held by that environment. To the extent that the aims and priorities established by the system are consistent with those expectations, it may be said that the system is in harmony with its environment. Controls established by the system in the form of rules, regulations, and resource allocations may or may not facilitate the accomplishment of those aims and priorities. The aims established by the system need to be translated into objectives. The relative importance of the objectives established for the system serves to identify priorities.

Resource Input Mix(es).--A major task of the school staff is to take the human and material resources made available to the school and, within the constraints imposed by aims, priorities, and controls established by the school, identify the most appropriate manner(s) in which to combine those resources to achieve the goals and objectives of the system. It is at this stage that the resource inputs of the system are translated into programs and services. There are numerous resource mixes in an educational system. The major elements of the resource mix are the instructional content of the program and the instructional process employed in conducting the program. Each instructional program involves the specification of objectives and prerequisites, decisions concerning the number of curricular levels, the time allocated to various elements of the program, the nature and quantity of instructional materials and equipment which will be required, the student grouping patterns, whether flexible or rigid, which need to be established, and the way space is to be utilized within the building. Other characteristics which may be important include the manner in which student progress is assessed, how information is managed, and how the instructional, support, and administrative staffs are patterned and organized relative to the program. The supportive services which must be provided to the program at the proper times and in proper amounts must be identified. The resources which are consumed in providing an educational program may then be translated into program costs. The economic comparison of alternatives is feasible when cost information is related to the outputs obtained from each program.

Outputs of the Educational System

Another component of the conceptual framework is the output of the educational system. It is convenient to divide output into two categories: (1) monetary outputs, and (2) nonmonetary outputs. Since economic analysis is concerned with quantifiable results, the outputs must be expressed in either monetary or measurable nonmonetary terms.

The outputs of the educational system are compared to the objectives established for the system to assess its effectiveness and efficiency. It is at this point that evaluation of the system's performance occurs. Evaluation produces feedback, which serves to let the system know how well it is functioning and triggers corrective action when such action is needed.

Nonmonetary outputs of the educational process may be expressed in a number of ways and often are proxy measures of quality. Expressions of outputs most often are short range and take the form of cognitive, affective, or psychomotor learning measured while a student is directly associated with the system. Some outputs may be measured by standardized achievement tests or tests of basic knowledge; other outputs may be demonstrated by performance of skills; and still others are best evaluated through anecdotal records and observations.

The long range outputs of the school are basically individuals who are well equipped to function as productive participating members of society. The effect of the school on long range outputs is even more difficult to determine than its effect on short range outputs, for other systems will influence the individual's ability to function in society. The indicators of long range outputs are also more ambiguous than those for the short range outputs. Indicators of long range outputs may be such items of information as participation as a citizen in government and social activities, voting behavior, work record, and similar proxy measures of a useful and productive life.

Joint outcomes of the educational system occur whether or not they are planned. They are incidental outcomes or by-products of the educational process, for example, staff morale.

Monetary outputs of the educational system are measurable in dollar terms and denote internal or private benefits which accrue to one who is a product of the educational system as a value stream of benefits, for example, personal income.

External or social benefits, which accrue to other than a student or his family, for example, contribution to the gross national product, are also monetary outputs. These are generally long range outputs. Joint outcomes are also represented in this category.

Feedback

The last component of the conceptual framework is feedback. It is feedback that provides the self-correcting mechanism for the system. Feedback is based on evaluation, whereby program output is compared to program objectives. Evaluating the productivity of the system is the means through which system managers are in a position to alter or endorse input mixes or resource allocations. With feedback, the external environment is better able to evaluate the system or the system's components and thus reassess its attitudes and expectations of the system or economic resources committed to it.

Requirements of a Cost-Effectiveness/Productivity Model

In addition to the design requirements of the model stipulated in the problem statement, which stem from the model's purpose, other more general requirements must be acknowledged. These requirements are drawn from the literature on basic design of systems models, the economic and systems framework for cost-effectiveness (Chapter I), cost-effectiveness (Chapter II), and productivity (Chapter III).

Basic Design Requirements of Systems Models in General

A conceptual framework of education subject to systems analysis should function as a "wide-angled lens trained on an organism so that it can be seen in its entirety, including the relationships among its parts and between the organism and its environment."[28] Subsequently, activities of the system, which are consciously organized for the express purpose of achieving certain educational objectives, may be evaluated and made more relevant, efficient, and effective.

An analytical model designed to conduct economic evaluations on an educational system, such as the one proposed by Rossmiller, Marinelli, and Geske,[29] should not only subscribe to the basic design requirements of systems models,[30] but also should integrate well with the components of the educational model under examination.

The analytical systems model should serve as a map which identifies the key elements of the system and specifies the relationship between those elements. The contents of the map are restricted to those elements and relationships which have a high probability of being suitable for the analytical purpose for which the model is being developed. In the present case, that purpose is cost-effectiveness. The system resembles a network or flow diagram, whereby the links will show the sequence of analytical operations. Only important relationships are included within the system boundary. Relationships that either affect the analytical model or are affected by the model, for example, its relationship to a conceptual framework of the education production process, are shown entering or leaving the boundary. In order to describe adequately the operation of analysis, a directed flow diagram indicates with arrowheads the direction of perceived relationships or the effects produced by one element on another. Arrows that cross the boundary represent the inputs and outputs to and from the system.

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[28] Philip H. Coombs, THE WORLD EDUCATIONAL CRISIS: A SYSTEMS ANALYSIS, (New York: Oxford University Press, 1968), p. 8.

[29] Rossmiller, Marinelli, and Geske, ECONOMIC ANALYSIS OF EDUCATION.

[30] The following discussion describing the basic design of a systems model is adapted from Van Court Hare, Jr., SYSTEMS ANALYSIS: A DIAGNOSTIC APPROACH, (New York: Harcourt, Brace and World, 1967), pp. 13-19, 27-32.

An analysis of an educational system may be conducted to predict input-output relationships. The analytical process isolates the inputs and outputs of the educational system in order to determine the structure within the system boundary that may affect the prediction. One product of the analytical process may be the improvement of the educational system's structural description, that is, an increased understanding of the educational process that converts inputs to outputs. The transformation process may be viewed as a "black box," wherein a level of detail concerning the relationships within the educational process is unknown. The exact details of how a transformation takes place is not required, but observation and assessment of what does occur is necessary in order to provide reliable input-output predictions.

The behavioral or operational definition of a "black box" (educational process) assumes that the relationship between the components of the educational system and/or external forces which influence the system will not change rapidly over time and thus invalidate the results of the analysis.

Requirements Drawn from the Economic and Systems Framework for Cost-Effectiveness

Since cost-effectiveness is an economic and systems approach to analysis, it should incorporate the essential concepts of economic and systems as discussed in Chapter I and listed below:

(1) The value of education should be ascertained in economic terms, whereby a dollar value may be placed on education or, at the very least, the output is quantifiable, in order to compare the returns from alternative investments in education.

(2) Educational costs should include, where possible, direct and indirect, social and private, and monetary and nonmonetary resource consumption.

(3) Techniques of economic analysis should seek to answer questions related to efficiency and productivity, since a central concept in economics is the efficient allocation of scarce resources to competing uses.

(4) Techniques of economic analysis must have built into them a conceptualization of the education production process within the educational system being evaluated.

(5) Economic decisions should rest on evaluations that have used timely and accurate information about an educational system's operation and performance.

(6) Economic analysis should aid in making educational enterprises more accountable for the results they produce.

(7) Competing alternatives should be evaluated and compared to ascertain if increased expenditure for traditional practices is the wisest investment decision.

(8) Systems analysis requires quantitative comparisons of educational systems.

Requirements Drawn From Cost-Effectiveness and Productivity Literature

Although descriptions of the role and analytical boundaries of cost-effectiveness have been the subject of controversy, some minimum requirements of a model may be drawn from the literature on cost-effectiveness which was reviewed in Chapter II.

(1) Information provided as a result of the analysis should sharpen intuition and judgment in decision making.

(2) Certain elements and procedures of the analytical process are essential. The analytical process must contain:

   (a) criteria against which to compare the performance of each alternative;

   (b) alternatives available for comparison;

   (c) measures and collection of cost and effectiveness data; and

   (d) integration of cost and effectiveness values into a decision framework and a display of non-quantifiable considerations and other uncertainties.

(3) The scientific method should be pursued within the analytical limitations presented by public policy and the educational setting. It includes:

   (a) intersubjectivity, that is, processes that can be duplicated;

   (b) explicitness, that is, the inclusion of methods of calculations, statements of assumptions, display of data and judgments; and

(c) objectivity, that is, the absence of conclusions that are based on personalities, reputations, or vested interests.

(4) Any effort to determine the productivity of educational systems or their components must account for the influence of extraneous sources on outputs.

Plan for the Model's Development

The development of the cost-effectiveness/productivity analytical model will be divided into two major steps. Step 1 consists of an analysis of the elements and procedures of the cost-effectiveness technique; Step 2 displays and discusses the model.

Analysis of the Elements and Procedures of Cost-Effectiveness

In Chapter V the elements and procedures of cost-effectiveness will be examined for the purposes of 1) identifying the essential factors within, boundaries of, and relationships between each element and procedure of the analysis in order to specify and describe the model and 2) providing some prescriptive guidelines to users of the model giving directions as to how to proceed through each step of the analysis.

The following steps have been identified as common to all the methods of cost-effectiveness which were reviewed and shall serve as the organizational framework for Chapter V:

(1) Specify the desired general goals and objectives that the alternative educational programs chosen for analysis are to fulfill.

(2) Distinguish the alternative programs.

(3) Specify evaluative criteria (measures) for cost.

(4) Determine the cost of each alternative.

(5) Specify evaluative criteria (measures) for effectiveness.

(6) Determine the effectiveness of each alternative.

(7) Display the results from cost and effectiveness determinations against the evaluative criteria.

(8) State the nonquantifiable and uncertainty factors.

(9) Merge cost and effectiveness information into a decision framework and document the merits of each alternative.

Specification of the Model

In Chapter VI a written description and graphic illustration of the analytical model will be provided. It shall consist of:

(1) an overall analytical process of the major elements and procedures which denotes costs, effectiveness/productivity, and integrates the cost and effectiveness components

(2) a model of each major component, of (1) above, that is, the nine steps above, displaying the essential factors and boundaries within it; and

(3) a model which relates the overall analytical model (1) to the conceptual framework of education as a system subject to economic analysis adopted in this study.

Evaluation of the Model

The model developed may be evaluated according to the problem statement and requirements of a cost-effectiveness/productivity model as follows:

(1) Does it meet the purposes for which it was developed?

(2) Does it meet the basic design requirements of general systems models?

(3) Does it meet the requirements of economic and systems analysis?

(4) Does it meet the basic requirements of cost-effectiveness and productivity analysis?

(5) Does it integrate well with its theoretical framework of education as a system subject to economic analysis?

Final judgment concerning the model's worth must rest on its evaluation through case studies and field tryouts in future research efforts.

Summary

The Wisconsin Research and Development Center for Cognitive Learning at the University of Wisconsin-Madison has developed the system of Individually Guided Education (IGE) as an alternative system of education. The Center has launched efforts to assess the impact of IGE on student outcomes. The assessment includes an evaluation of the productivity of IGE's organization for instruction and administrative arrangements relative to other instructional and administrative strategies through the technique of cost-effectiveness analysis. The results of evaluation will assist practitioners and IGE designers and implementors in improving the system. It was the purpose of this study to 1) review the literature relative to cost-effectiveness in order to ascertain the state of the art and to identify models which have been employed in research on productivity and 2) develop a prototype cost-effectiveness model incorporating indicators of human and material resource input and cognitive and affective output.

It is evident from the review of the literature on the economic and systems framework for cost-effectiveness, cost-effectiveness, and productivity contained in Chapters I through III, respectively, that an appropriate model is unavailable—a model which focuses on the analytical process, incorporates resource configurations and output indicators, and is applicable to programs in operation in the natural school setting.

The model is based on a conceptual framework of education as a system subject to economic analysis. In addition to the requirements of an analytical model which stem from the problem statement, other criteria were revealed by the literature review. The model should meet the basic graphic descriptive requirements of any systems model by mapping out components, their boundaries, and the direction of their interrelationships. It should integrate with the components of the educational process and, by so doing, should assist in improving the explanatory power of a theoretical model of the education production process. Techniques of economic analysis should compare the relative efficiency and productivity of competing alternatives using several dimensions of resource consumption as they relate to outputs from timely and accurate data. The results of the evaluation should provide information for wise investment decisions.

The essential elements of the analytical model include performance criteria for measuring output, alternatives for comparison, collection and display of cost and effectiveness data, and a decision framework. The scientific method should be followed as nearly as possible.

An analysis of the elements and procedures drawn from the literature will be conducted to reveal the essential factors within boundaries of, and relationships between each element and procedure. Such an analysis will provide some prescriptive guidelines to potential users of the model.

Several submodels will be developed to complement the overall model. Five questions have been posed to serve as evaluative criteria for the model's merit.

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WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

Technical Report No. 390

(Part 2 of 3 Parts)

AN ANALYTICAL PROCESS MODEL FOR COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS OF ALTERNATIVE EDUCATIONAL PROGRAMS

by

Joseph J. Marinelli

Report from the Project on
Organization for Instruction and
Administrative Arrangements

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July 1976

This Technical Report is a doctoral dissertation reporting research supported by the Wisconsin Research and Development Center for Cognitive Learning. Since it has been approved by a University Examining Committee, it has not been reviewed by the Center. It is published by the Center as a record of some of the Center's activities and as a service to the student. The bound original is in the University of Wisconsin Memorial Library.

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WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

MISSION

The mission of the Wisconsin Research and Development Center for Cognitive Learning is to help learners develop as rapidly and effectively as possible their potential as human beings and as contributing members of society. The R&D Center is striving to fulfill this goal by

- conducting research to discover more about how children learn
- developing improved instructional strategies, processes and materials for school administrators, teachers, and children, and
- offering assistance to educators and citizens which will help transfer the outcomes of research and development into practice

PROGRAM

The activities of the Wisconsin R&D Center are organized around one unifying theme, Individually Guided Education.

FUNDING

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ABSTRACT

AN ANALYTICAL PROCESS MODEL FOR COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS OF ALTERNATIVE EDUCATIONAL PROGRAMS

JOSEPH JOHN MARINELLI

Under the Supervision of Professor Richard A. Rossmiller

The purposes of this study were (1) to ascertain the state of the art with regard to cost-effectiveness and productivity analyses in education and (2) to develop an appropriate cost-effectiveness analytical process model for education.

Design of the Study

Specifications for the model required that it be integrated with a conceptual framework of formal education for economic analysis and that it conform to requirements drawn from (1) purposes of the study, (2) systems designs in general, (3) economic and systems theory and analyses, and (4) cost-effectiveness and productivity literature.

For purposes of this study, cost-effectiveness was defined as an economic and systems evaluation technique for comparing the productivity of pre-selected competing alternatives established for accomplishing some desired end, whereby the resource consumption and output, attributable only to each alternative, are integrated into a common decision framework.

Major Findings

Following review of the economic and systems framework within which cost-effectiveness evaluations operate, requirements for the model were stipulated from a discussion of the economic value, quantification, and costing of education, and techniques of economic and systems analysis related to efficiency and productivity. The cost-effectiveness review included a classification of the various applications (models) based upon different views of definition, role, analytical boundaries, research design, and procedures and specification of commonly recognized requirements. The review of productivity in education consisted of identifying and classifying input-output models of educational production, discussing analytical problems, and displaying the results of a number of studies in a manner consistent with the typology of inputs described in the educational system model adopted earlier.

To specify an analytical process model, the nine major generally recognized steps of cost-effectiveness evaluations were examined. This examination revealed the essential process elements and relationships within, boundaries of, and relationships between each step. The review included an examination of classifications of learning and objectives, curriculum descriptors, cost models and analyses, descriptive summary statistics, variables for selection for education production functions, and multivariate inferential statistical procedures. Some prescriptive guidelines and references were also provided for potential users of the model.

The general model and submodels representing each of the nine steps were specified in a network of flow diagrams showing the sequence of analytical operations and cause-effect relationships between process elements. The general model classifies the steps according to the three dimensions: cost, effectiveness/productivity, and integration of these two components. The submodels are:

1. Specify the desired goals and objectives that the alternative educational programs are to fulfill.
2. Distinguish the alternative programs.
3. Specify evaluative criteria (measures) of effectiveness.
4. Specify evaluative criteria (measures) of cost.
5. Determine the cost of each alternative.
6. Determine the effectiveness of each alternative.
7. Display the results from cost and effectiveness determinations against the evaluative criteria.
8. Merge cost and effectiveness information into a decision framework and document the merits of each alternative.
9. State the non-quantifiable and uncertainty factors.

Steps of the general model were integrated with the conceptual framework of an educational system from a viewpoint of economic analysis.

Implications

The prototype model developed in this research needs to be refined through the use of initial case studies and subsequent large scale field tryouts. It should provide practitioners with a methodology which can be employed to evaluate the productivity of Individually Guided Education and other educational programs and to provide feedback from the field

to program designers, implementors, and evaluators. An analytical process model of this type allows for research on direct applications of cost-effectiveness analysis to instructional programs and processes. Thus the systematic consideration of alternatives including new instructional methodologies should be advanced.

Approved by Richard A. Rossmiller
Richard A. Rossmiller

Date May 27, 1976

CHAPTER V

ANALYSIS OF THE MAJOR STEPS AND PROCESS ELEMENTS OF COST-EFFECTIVENESS

In specifying an analytical model, it is first necessary to examine the basic elements and procedures of cost-effectiveness, which can be identified through the literature, in order to discover the essential factors within, boundaries of, and relationships between each element and procedure. A literature review for each step of the procedure was conducted to accomplish this purpose. As a consequence of the review, some prescriptive guidelines and references are provided concerning ways to proceed within each step of the analysis. The chapter is organized into nine sections:

1. Specify the goals and objectives that the alternative educational programs are to fulfill.
2. Distinguish the alternative programs.
3. Specify evaluative criteria (measures) of effectiveness.
4. Specify evaluative criteria (measures) of cost.
5. Determine the cost of each alternative.
6. Determine the effectiveness of each alternative.
7. Display the results from cost and effectiveness determinations against evaluative criteria.
8. State the non-quantifiable and uncertainty factors.
9. Merge cost and effectiveness information into a decision framework and document the merits of each alternative.

Specify the Goals and Objectives That the Alternative Educational Programs Are to Fulfill

A review of Step 1 of the analysis revealed that the related literature could be grouped according to the following topics: description of desirable goals, objectives, and competencies for which alternatives were chosen; conceptual bases for organizing the desired outcomes of each alternative; considerations in the classification of learning; taxonomies of learning; specification of objectives; identification of target groups; and ranking of objectives and processes.

Description of Desirable Goals, Objectives, and Competencies for Which Alternatives Were Chosen

Desirable general goals, objectives, and competencies should stem from a problem statement which created the need for comparing the cost-effectiveness of competing program alternatives. Pearson[1] suggested that if goals and objectives are too general in nature then the subsequent evaluation of alternatives may not measure precisely that which is intended. The goals and objectives also may be identified in such a manner as to bias the evaluation if specific requirements exclude potential program alternatives from consideration. In addition, if goals or objectives are too specific, they may be, in essence, implicitly defining the concepts and contents of an alternative, rather than general desired goals or objectives for which the alternatives are chosen. He also suggested that unattainable goals and objectives should not be specified. A subsequent activity to identification of goals and objectives is the listing of the general competencies and the level of performance which the learner is expected to demonstrate.

---

[1] Robert Hardy Pearson, "A Study of Cost-Effectiveness Analysis with Implications for Instructional Decision-Making," (unpublished Ph.D. dissertation, Syracuse University, 1972), pp. 36-37.

Conceptual Base for Organizing the Desired Outcomes of Each Alternative

To evaluate the instructional models of program alternatives, Lohnes[2] suggested that one begin with a delineation of each alternative's theories of intelligence, personality, and instruction:

> The need for delineation of an adequate theory of intelligence in particular and personality in general to organize the criterion domain. Long lists of specific behavioral objectives, although essential for the engineering of a curriculum, are not a substitute for the required theory.
>
> The need for a theory of instruction to organize the treatment domain. What are the significant dimensions on which instructional models differ: It should be possible to measure the degrees of realization of various stimulus condition desiderata under different instructional models, rather than simply count them as present or absent. Treatments are more realistically viewed as differing in degrees of emphasis, rather than in absolute kind.[3]

For example, Lohnes[4] delineated the Learning Resource and Development Center's (LRDC) Instructional Model which rests on four principles--individualization, learning hierarchies, behavioral objectives, and reinforcement and motivation. The LRDC theory has replaced generalized traits with learning hierarchies to explain the structure of cognitive behaviors. The LRDC model apparently follows Gagne's[5] theory of a hierarchy of learning sets mediating learning performance. Thus, the amounts and kinds of available relevant knowledge which may be used to describe individual student differences are accounted for by differences in individual rates of achievement. The structure of knowledge is organized in pyramidal fashion. Subordinate knowledge sets are preconditions for the transfer of learning to higher level knowledge sets. By acquiring specific knowledges at the aptitude or the lowest level learning sets, one ultimately may acquire complex abilities or higher mental processes by the continuous transfer of learning through sequential learning sets.

---

[2] Paul R. Lohnes, PLANNING FOR EVALUATION OF THE LRDC INSTRUCTIONAL MODEL, A Monograph, (Pittsburgh, PA: Learning Research and Development Center, University of Pittsburgh, 1972), p. 1.

[3] Ibid., p. 1

[4] Ibid., pp. 8, 26.

[5] R. M. Gagne and N. E. Paradise, "Abilities and Learning Sets in Knowledge Acquisition," PSYCHOLOGICAL MONOGRAPHS, 75, (1961), 14.

Considerations in the Classification of Learning

Kazanowski mentioned two cost-effectiveness considerations related to the identification of goals, objectives, and competencies:

> Goals, objectives, and competencies must be converted into some unit of measure for both cost and effectiveness.
>
> Errors of commission are just as important as errors of omission. If goals or objectives that are not necessarily essential are identified as requirements, they can strongly prejudice the subsequent cost-effectiveness evaluation.[6]

Subsequent to the specification of conceptual frameworks of intelligence, personality, and instruction, consideration is given to the listing of desirable outcomes. Learning hierarchies aid in distinguishing alternatives. Several considerations should be confronted, however, when laying out learning hierarchies.

---

[6] A. D. Kazanowski, "The Standard Approach," in J. M. English (ed.), COST-EFFECTIVENESS: THE ECONOMIC EVALUATION OF ENGINEERED SYSTEMS, (New York: Wiley, 1968), pp. 117-119.

1. A learning hierarchy presumes that a student is developing a complex ability or higher mental process that can be delineated as a trait and designated by an appropriate trait name.

2. If several habits are under development, within a unit or an entire curriculum component, the pyramidal map ought to show levels of frewer and more comprehensive, generalized knowledges as it is read upwards. If there is no summit there is no pyramid to be named as a trait.

3. A student's position on a map with alternative paths may be an ambiguous measurement of his achievement. If a student has forgotten what he learned, his present position may merely show where he is "lost" in a maze.

4. It is possible that other sequences of learnings that lead to the same summit ability could be created for or even invented by students.

5. Must learning hierarchies necessarily correspond to traditional subject matter areas? If students need to develop particular generalized communicational, logical, and analytical abilities, they can be accomplished by the use of a variety of content materials.

6. Learning hierarchies can make explicit the transfer values of what is learned, i.e., mastery of learnings that have been carefully selected for their transfer values.

7. Does an analysis of learning hierarchies account for the incidental learnings that occur in any educational program? Unplanned results may be both good and bad. Such learning may include attitudes, appreciations, and interests.

8. Many planned and incidental learning objectives, that cannot be measured by maximum performance items, are important.[7]

Lohnes cautioned that learning hierarchies of intellectual traits by themselves are not sufficient in curricular evaluation. Substantial attention should be given to curricular outcomes such as student motives, values, plans, interests, and attitudes.

---

[7] Lohnes, PLANNING FOR EVALUATION, pp. 27-34.

Taxonomies of Learning

Several taxonomies have been proposed for viewing domains of learning experiences. Bolen[8] developed a schema for constructing systematic instructional sequences to accommodate learning differences. (See Figure 5.1). His schema recognizes the existence of skills, knowledge, and attitudes to be acquired in perceptual-motor, perceptual, and associative-conceptual hierarchical learning levels.

Learning Levels	Skills	Knowledge	Attitudes
1. Perceptual-Motor (Identifying)	Perceptual-Motor	Multi-Sensory Approach	Self
2. Perceptual (Integrating)	Readiness	Exploratory	Social
3. Associative-Conceptual (Interpreting)	Academic	Patterned	Work Oriented

Figure 5.1--Schema for Learning Experiences

Source: John E. Bolen, "Toward a Taxonomy of Curricular Experiences," JOURNAL OF LEARNING DISABILITIES, 3 (May, 1970), p. 11.

Bloom[9] specified a hierarchical achievement paridigm for the cognitive domain to include knowledge, comprehension, application, analysis, synthesis, and evaluation. Krathwohl[10] and others proposed a similar paradigm for the affective domain to include receiving (attending), responding, valuing, organization (of a value system), and characterization by a value or value complex.

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[8] John E. Bolen, "Toward a Taxonomy of Curricular Experiences," JOURNAL OF LEARNING DISABILITIES, 3 (May, 1970), 10-14.

[9] Benjamin S. Bloom (ed.), TAXONOMY OF EDUCATIONAL OBJECTIVES, HANDBOOK I: COGNITIVE DOMAIN, (New York: McKay, 1956).

[10] David R. Krathwohl, Benjamin S. Bloom, and Bertram B. Masia, TAXONOMY OF EDUCATIONAL OBJECTIVES, HANDBOOK II: AFFECTIVE DOMAIN, (New York: Mckay, 1964).

Specification of Objectives

Three elements of an objective that should be specified in writing have been identified:

1. An action--what the student is supposed to be able to do when he is evaluated--which is communicated by means of action words such as identify, write, list, and contract. [Other action words include name, describe, construct, order, and demonstrate];[11]
2. A context or signal--the conditions under which the student will be evaluated--which might be implied or stated in a phrase frequently beginning with the word "given"; and
3. A criterion--the level of performance expected of the student in which quality and/or quantity expectations are stated.[12]

Identification of Target Groups

In addition to classifying learning outputs according to major types of learning that are being sought, within a program structure, e.g., the development of basic and individual fulfillment skills, and moral and social objectives, outputs may be specified or designated for various target groups. Mushkin and Cleveland[13] suggested (see

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[11] Howard J. Sullivan cited in Philip G. Kapfer, "Behavioral Objectives and the Curriculum Processor," EDUCATIONAL TECHNOLOGY, (May, 1970), 15.

[12] Robert F. Mager cited in Ibid., 14.

[13] Selma J. Mushkin and James R. Cleaveland, PLANNING TIONAL DEVELOPMENT IN A PLANNING, PROGRAMMING, BUDGETING SYSTEM, State-Local Finances Project, George Washington University, (Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1968), pp. 16, 18.

Figure 5.2) that, although a program may serve several target groups, certain children may receive different services based on factors such as learning problems or socioeconomic status.

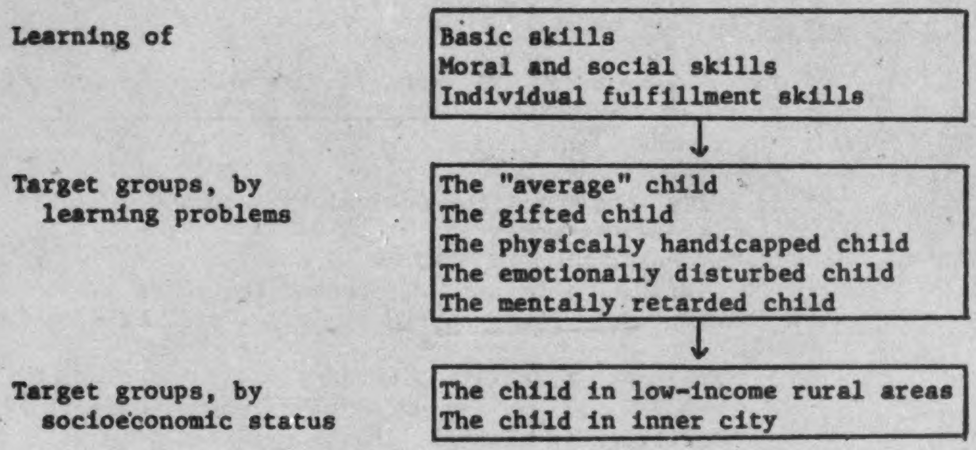
Learning of
Basic skills
Moral and social skills
Individual fulfillment skills
Target groups, by learning problems
The "average" child
The gifted child
The physically handicapped child
The emotionally disturbed child
The mentally retarded child
Target groups, by socioeconomic status
The child in low-income rural areas
The child in inner city

Figure 5.2--Identification of Target Groups

Source: Selma Mushkin and James R. Cleaveland, PLANNING FOR EDUCATIONAL DEVELOPMENT IN A PLANNING, PROGRAMMING, BUDGETING SYSTEM, State-Local Finances Project, George Washington University, (Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1968), p. 19.

Ranking of Objectives and Processes

Program objectives may be rank ordered so that measured achievement levels can be weighed against the relative importance of achieving an objective. In addition, various program processes may be prioritized as to their relative utility in achieving each objective. This allows for a comparison between processes within a program or between programs to achieve the same objective. Curtis suggested a procedure to accomplish this end.

1. Selection of a panel of judges for the initiation of a jury approach to the rank ordering of objectives and processes.

2. Ranking of objectives by the jury members in terms of their immediate importance (i.e., importance of their attainment at the end of one academic year).

3. Ranking of processes by the jury members in terms of the contribution of the process to the attainment of each objective.

4. The conversion of ranking to weighted decimal scores.

5. Determination of a utility value for each process based on the weighted decimal scores.[14]

Distinguish the Alternative Programs

In this section, the review includes taxonomic considerations and suggested taxonomies for the purpose of distinguishing between competing alternatives. Haggart said that the first step in analyzing the resource requirements and cost of a program is the definition of the program.

> The quality of the estimate of the cost of an educational program depends on the completeness with which the resource requirements of the program are determined. This determination, in turn, depends on the description of the educational program. The sequence of events then begins with a description of what the program is and how the program works and continues with a determination of the quality and quantity of the resources. These resource requirements are translated into an estimate of the program dollar cost. In defining the program, the types and magnitudes of support activities or services needs to be identified.[15]

An instructional strategy is at the heart of educational programs. Instructional strategies by their very nature, require different combinations of resources. The differences may be quantitative or qualitative and are evident in a number of program characteristics.

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[14] William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corporation, Association of School Business Officials, 1971), p. 244.

[15] Sue A. Haggart, "Program Cost Analysis in Educational Planning," (paper presented at the National Conference on Performance Contracting in Education, Washington, D.C., December 9 and 10, 1971), p. 5.

Taxonomic Considerations

A common set of characteristics must be selected if one is to make resource comparisons between educational programs. Barro[16] listed two important considerations in selecting a set of characteristics--generality and compactness. "Generality" means that the set of characteristics is flexible enough to describe numerous organizational and operational structures. It should accommodate novel or innovative delivery systems. Such generalized representations are "prerequisite(s) for the development of broadly applicable tools of cost and effectiveness analysis." "Compactness" means that programs can be described with an analytical framework within which a reasonably concise set of constructs and categories may be applied to many kinds of resource allocation questions."[17]

Deloria[18] and his associates, after reviewing other research findings, called for a careful delineation of implementation methods used with the curriculum involved because (1) there may be different classroom interpretations of a specified curriculum, and (2) the actual implementation of apparently different curriculum might reveal much similarity between them.

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[16] S. M. Barro, "Modeling Resource Utilization in A School District," in Sue A. Haggart, et al., PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, (Santa Monica, CA: Rand, 1969), pp. 66-67.

[17] Ibid., pp. 66-67.

[18] Dennis J. Deloria, et al., "A Design for a National Day Care Cost-Effectiveness Experiment," Final Report, (Ypsilanti, MI: High/Scope Educational Research Foundation, March, 1972) p. 3-2.

> ...Without knowing what specific treatments each group received, it would be difficult to conclude anything about the differences found on the outcome measures; second, if the implementat[ed] curricula differ from those specified by the curriculum planners, it would not be possible to make conclusions about the effectiveness of the intended curriculum.[19]

Suggested Taxonomies

Barro listed and described a set of instructional design and resource variables which have a direct relationship to resource requirements, cost, and perhaps to instructional effectiveness. Instructional design encompasses the specification of the (1) horizontal organization of instruction, (2) group or class sizes, (3) resource inputs, and (4) instructional methods. The first three were defined as follows:

1. Horizontal organization refers to the set of specifications that tell us how students at a given level of instruction are assigned to groups or classes and how the groups are assigned to teachers and classrooms for instruction. Examples: self-contained classrooms, full or partial departmentalism, team teaching or other flexible grouping arrangements, and so forth.

2. Group size or class size tells us how many students are exposed as a unit to each form of instruction. It is a "scale factor" with respect to many of the specifications of resource inputs.

3. Resource input specifications define the number of units of resource services associated with a unit of each form of instruction. Examples: teachers per class hour, equipment per number of classes, materials per student--hour, textbooks per number of students.[20]

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[19] _Ibid_., p. 3-2.

[20] Barro, PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING, pp. 77-82.

In addition to instructional design variables, the resources supplied by instructional support programs and the auxiliary services required for carrying out instructional programs were specified. Barro would aggregate required resource data to represent major groupings of similar resources.

Haggart[21] designed the following format for program and resource information:

Characteristics of students served

Number of Students

Instructional Data
  Class Time
  Class Size

Facilities (school and non-school)
  Space
  Students/classroom/day
  Utilization (rates)
  Furnishings (per student)

Staffing (time involved)
  Teachers
  Special Teachers
  Paraprofessionals
  Other personnel

Equipment (lifetime nature of)
  Program-related
  Student-related

Preservice training ←——— amount of time involved; materials
                                     and equipment required during
In-service training ←——— regular time or incremental to regular
                                     working hours; substitutes required.
Other Support

Figure 5.3--Format for Program and Resource Information

Source: Adapted from Sue A. Haggart, "Program Cost Analysis in Educational Planning," (paper presented at the National Conference on Performance Contracting in Education, Washington, D.C., December 9 and 10, 1971), p. 6.

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[21] Haggart, "Program Cost Analysis in Educational Planning," pp. 5-8.

Cooley identified curricular process variables that are critical to the Learning Research and Development Center's instructional model. Seven domains of classroom characteristics seemed to distinguish classroom activities:

1. Testing practices;
2. Prescription practices;
3. Travelling skills of teachers (how the teacher moves about the classroom, reinforcing appropriate student behavior);
4. Instructional materials actually used;
5. Allocation of time;
6. Space and its utilization; and
7. Teachers' knowledge of the curriculum and the children in her charge.[22]

In the testing practices domain (1 above), he defined ways in which such practices might vary according to:

1. Frequency of individual testing;
2. Accuracy of scoring and recording test results;
3. Location of testing area in the classroom;
4. Use of mastery level; and
5. Testing all terminal objectives1

Measures of the above processes are intended to display the degree of instructional model implementation.

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[22] William W. Cooley, "Methods of Evaluating School Innovations," (Invited address to the 79th Annual Convention, American Psychological Association, Washington, D.C., September 3, 1971), p. 12.

Another schema, developed by DeVault[23] and others for the analysis of various individualized curricula, rates program organization, instructional processes, and associated media according to the following taxonomy:

1. Program pattern
    Objectives
    Sequence
    Rate
    Medium
    Grouping
2. Learner assessment procedures
3. Management of information
4. Management of instructional components

Quilling[24] identified four general descriptors of content and instructional processes. The descriptors are curriculum decision unit size, rate adaptiveness, structural granularity of the content, and content difficulty. Curriculum decision units are conceived as points on a continuum which partition the curriculum into segments about which important instructional or evaluative decisions are made--units which form the framework for the teacher's instructional scheduling. Curriculum decision unit size can be measured in terms of the time devoted to instruction until a key scheduling or evaluative decision is made. The unit size may vary for individuals within the group or be constant for the group. A mean of means for all decision units is an expression of the average time between key instructional programming and evaluative decisions. The substantive elements of a curriculum may be identified at several levels of specificity as Krathwohl[25] and Flanagan and others[26] have indicated. Chapters in a textbook, topical subsections of a curriculum, programmed instruction frames, or specific behavioral objectives may serve as examples of curriculum decision units.

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[23] M. V. DeVault, et al., DESCRIPTOR FOR THE ANALYSIS OF INDIVIDUALIZED INSTRUCTION, (Madison, WI: Wisconsin Center for the Analysis of Individualized Instruction, 1973).

[24] Mary R. Quilling, "A Data Analysis Approach to Evaluating Achievement Outcomes of Instruction," (unpublished Ph.D. dissertation, University of Wisconsin-Madison, 1973), pp. 69-75.

Rate adaptiveness refers to the adjustment of time spent by each student on a particular curriculum decision unit. Quilling devised a measure of the range of time spent on each curriculum decision unit. The summary measure, f, is an average across curriculum units, for each of which the range is scaled by its midpoint:

$$f = \sum_{i} \frac{1/2\,(t_{max} - t_{min})}{t_{mid}} \bigg/ w$$

$$= \frac{1}{2w} \sum_{i} \frac{(t_{max} - t_{min}}{t_{mid}} \qquad \text{where } i - 1, 2, \ldots, w$$

t_{max}	is the maximum time, in number of instructional periods, spent on a given curriculum decision unit by an individual within the group.
t_{min}	is the minimum time, in number of instructional periods, spent on a given curriculum decision unit by and by an individual within the group.

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[25] D. R. Krathwohl, "Stating Objectives Appropriately for Program, for Curriculum, and for Instructional Materials Development," JOURNAL OF TEACHER EDUCATION, 16, (1965), 83-92.

[26] J. C. Flanagan, et al., SCIENCE BEHAVIORAL OBJECTIVES: A GUIDE TO INDIVIDUALIZED LEARNING, (Palo Alto, CA: Westinghouse Learning Press, 1971).

t_{mid} is half the distance between t_{max} and t_{min}

w is the number of curriculum decision units presented instructionally.[27]

Structural granularity of the content refers to the content chunks of various sizes within curriculum decision units. Each is associated with some instructional step leading toward completion of the unit. Structural granularity may be measured by the average number of instructional days spent on each instructional step. Equivalent measures are obtained calculating the average time within or across curriculum decision units.

Content difficulty (puissance) from various printed materials may be sampled and evaluated to determine the level of difficulty of the content. The difficulty is evaluated in terms of Walbesser's[28] matrix of categories of conceptual and performance elements. Of the four Quilling[29] variables tested, only the measure of content difficulty failed to discriminate among the various programs due, at least in part, to the great difficulty in classifying content according to Walbesser's matrix.

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[27] In effect the numerator in the first expression for f denotes the maximum observed deviation from the midpoint of time spent by the class scaled by the midpoint of the range; this quantity is a proportional descriptor of the time that may be added to or subtracted from the midpoint of time spent on a given unit by individuals in the class. The value of f is an average of these proportional deviations and ranges from 0, when there is no variation, to 1 when the range is twice its midpoint. An example will clarify the interpretation: for a curriculum decision unit on which individuals spent 10 to 20 instructional periods, the value of f is .33, indicating that individuals could vary by as much as one-third from the 15-period midpoint. The distribution is probably unimodal with positive skew.

[28] H. H. Walbesser, "Behavioral Objectives, A Cause Alebre," THE ARITHMETIC TEACHER, 19 (1972), 436-440.

[29] Quilling, "A Data Analysis Approach," p. 131.

Inglis, et al.,[30] have illustrated in tabular form a comparison of the differences that exist between a traditional mathematics program and IGE's Developing Mathematical Processes program.

Specify Evaluative Criteria (Measures) of Effectiveness

This section is concerned with identifying essential factors in the adoption, adaptation, development and use of effectiveness measures. The literature related to this task includes general considerations and problems, realiability and validity, achievement tests and attitude scales, and norm-referenced and criterion referenced tests.

Some General Considerations and Problems

An examination of the literature may reveal valid and reliable measures of effectiveness. Unique measures may be developed which satisfy the basic criteria of measuring instruments. If the development of a specific measuring instrument is not possible due to lack of sufficient time or resources, then an instrument which offers the best fit between test items and program objectives may be adopted or adapted. In all likelihood, this compromise will reduce the amount of information bearing on the success of a program. In constructing measures of effectiveness, one must resolve test item bias and sampling problems. If it

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[30] Joan D. Inglis, *et al.*, "CBTE and the Basic School Subjects," in PARTNERS FOR EDUCATIONAL REFORM AND RENEWAL, George E. Dixon, *et al.*, (Eds.), (Berkeley, CA: McCutchan, 1973), pp. 185-6.

Traditional	Individualized
Instructional groups are formed by homeroom assignments for each year.	Instructional groups are formed by preassessment for each topic or skill.
The adopted textbook is the content.	Teachers decide what a student is expected to learn by defining instructional objectives.
The instructional needs of each student are met within the two covers of the textbook, with all students expected to complete the same assignments.	Based on the specific objectives stated for each mathematical topic or skill, the following questions are answered before a student begins instruction: (1) How much of what is to be learned is already known? (2) Does the student have the necessary capabilities for the instruction to be presented? (3) What instructional activities should be prescribed for each student?
Manipulatives do not comprise an integral part of the mathematics program and are seldom used by all students.	Manipulatives are required and purchased as a part of the individualized program; all students use the manipulatives and are capable of demonstrating mathematics principles with them.
Instruction is sometimes facilitated by ability grouping within a classroom or by departmentalization. Once these groups are formed, they usually remain as groups for a year with students moving when they are unable to fit into a group.	Students constantly interact with each other in discussing, explaining, and sharing mathematical ideas. Individualized instruction permits students to work alone but does not preclude small and large group instruction. Groups are formed by tasks, interests, abilities, etc.; if a student does not fit into a group the instruction is changed to meet his needs.
All elementary students are placed in the textbook that corresponds to their grade level in schools. Weekly and unit tests are used to measure the progress of all students.	All elementary students are given a placement test and then placed at their achievement level in each mathematical topic. After the level of achievement is established, topic tests are used to determine the knowledge each student has of specific operations and skills before and after instruction.
Evaluation is measured only at the end of a unit or a grading period. The grade on the report card is the evaluation.	Continuous evaluation and remediation provides each student with feedback of his errors, which enables him to identify his mistakes and correct them. A record-keeping system is jointly kept by the student and his teacher. Instruction is continually offered at an appropriate level for each student.
Evaluation of the students is done by the teacher and the answer key of the textbook.	Self-evaluations help the students validate their progress for the teacher and then plan with the teacher for subsequent instruction.

Figure 5.4--Comparison of Traditional and Individualized Mathematics Programs

Source: Joan Inglis, et al., "CBTE and the Basic School Subjects," in PARTNERS FOR EDUCATION REFORM AND RENEWAL, George E. Dixon, et al., (eds.), (Berkeley, CA: McCutchan, 1973), pp. 185-6.

is not possible to measure the attainment of all objectives for every student, then a probability sample which accurately represents the total population of objectives and students may be selected. The size of the sample to be acquired depends on such technical considerations as variance in the distribution of the quality being measured, the amount of change expected as a result of program activity, and the level of certainty desired when inferring that what is true of the sample is also true of the population from which it was drawn.[31]

Bormuth listed three requirements to improve program evaluation techniques:

> 1. They must permit us to enumerate exhaustively the behavior that can be acquired as a result of exposure to a course of instruction. The resulting knowledge will allow us to inspect thoroughly the effects of a program and to draw a set of items that will enable us to examine an unbiased sample of those behaviors.
>
> 2. Our test construction techniques must permit us to derive the test items in a mechanical and completely reproducible process.
>
> 3. If taxonomic classifications are to be used in any way to describe the items so derived, these taxonomic classes must be defined in terms of the transformations by which they were derived from the instructional stimuli.[32]

Bormuth would argue that, since these requirements are not currently being met, decisions based upon program evaluations must be guarded. The source of the problem stems from the mismatch between the observation of student responses to some sort of tasks (test items) and program objectives.

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[31] Deniston, et al., PLANNING PROGRAMMING BUDGETING, p. 156.

[32] John Bormuth, "Comments on Professor Alkin's Paper Entitled 'Evaluating the Cost-Effectiveness of Instructional Programs,'" (from the proceedings of the SYMPOSIUM ON PROBLEMS IN THE EVALUATION OF INSTRUCTION, Sponsored by the Center for the Study of Evaluation, UCLA, in December, 1967), pp. 4, 6.

Whereas differences in scores may reflect differences in the characteristics being measured, the existence of transitory factors, such as mood or fatigue, variations in the administration of a test, and the care with which instruments are used may bias the results. Mastery of complex concepts composed of many specific subconcepts is difficult to measure. One test may not measure all functions, and if the test had been constructed such that other functions were included, the results might have been different.[33]

Reliability and Validity

The effectiveness of a program or program element is an assessment of how much that program or program element contributed to the attainment of the objective(s). Reliable and valid measures of program accomplishment are required.

Reliability refers to the accuracy of precision of a measuring instrument, that is, the dependability, stability, consistency, predictability and accuracy of test scores. Kerlinger approached the definition of reliability in three ways, each epitomized by a question:

1. If we measure the same sets of objects again and again with the same or comparable measuring instrument, will we get the same or similar results?
2. Are the measures obtained from a measuring instrument the "true" measures of the property measured?

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[33] Deniston, et al, PLANNING PROGRAMMING BUDGETING, p. 155.

3. How much error of measurement is there in a measuring instrument?[34]

Random or error variance is self-compensating, whereas systematic variance is constant but biased. "Reliability can be defined as the relative absence of errors of measurement in a measuring instrument."[35]

Three types of validity exist: content, criterion-related and construct. Kerlinger noted that content validity is a measure of the "representativeness of sampling adequacy of the content--the substance, the matter, the topics--of a measuring instrument."[36] Content validity is guided by the question: Is the substance or content of this measure representative of the content or the universe of the content of the property being measured? Predictive and concurrent validity are criterion-related measures. They are characterized by prediction to an outside criterion and by checking a measuring instrument, either now (concurrent) or in the future (predictive), against some outcome or measure. Construct validity seeks to answer the questions: What psychological or other property or properties can "explain" the variance of the test, that is, the meaning of the test? What factors or constructs account for variance in test performance? It seeks to explain individual differences in test scores of a measuring instrument. The interest is in the property being measured, rather than in the test itself.

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[34] Fred N. Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, 2nd ed., (New York: Holt, Reinhart and Winston, 1973), pp. 457-62.

[35] Ibid., pp. 442-4.

[36] Ibid., p. 443.

Lohnes[37] related construct and content validity to formative and summative evaluation. Since test items should exactly measure specified curricular objectives, content validity is of the utmost importance in formative evalution. Criterion-referenced tests are most appropriate in formative evaluation. Since the transfer of learning, according to Lohnes, is more important than mastery learning and summative tests measure broad abilities and dispositions, construct validity should dominate summative testing.

Achievement Tests and Attitude Scales[38]

Achievement tests and attitude scales are relevant to measuring the effectiveness of educational programs. Achievement tests are intended to measure proficiency, mastery, and understanding of general and specific areas of knowledge, in other words, the effectiveness of instruction and learning. Achievement tests may be either standardized or specially constructed to measure limited areas of proficiency or achievement. Standardized achievement tests (typically group tests) are based on common general educational content and may consist of a battery of several tests which measure the most important areas of learning or a single test on individual subjects. Objective scales and items are of three types: agreement-disagreement (approve-disapprove, or true-false), rank order and forced choice.

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[37] Lohnes, PLANNING FOR EVALUATION OF THE LRDC INSTRUCTIONAL MODEL, pp. 60-67.

[38] For a complete discussion in this area, the reader is referred to Fred N. Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, SECOND EDITION, (New York: Holt, Rinehart and Winston, 1973), Chapter 29.

Attitude scales measure a predisposition towards a referent or cognitive object as observed through expressed thoughts, feelings, perceptions and behaviors. Referents are categories, classes, or sets of phenomena in the form of events, behaviors, or constructs. Three major types of attitude scales are available: summated rating scales, equal-appearing interval scales, and the cummulative scale. Although educational effectiveness research has been directed almost entirely toward cognitive achievement, the importance of non-cognitive factors should not be minimized. Non-cognitive factors are considered major determinants of cognitive achievement.

> Attitudes and motivation have strong intrinsic cognitive components, and cognitive skills and abilities have strong intrinsic noncognitive components.... Generalization of cognitive ability results not only from the transfer of specific skills, but also from such noncognitive factors as the establishment of learning styles, learning sets, motivation for learning, and attitudes about learning. Noncognitive factors undoubtedly outweigh the importance of specific cognitive skills for future learning, although acquiring cognitive skills may itself considerably affect noncognitive factors such as motivation, self-awareness, and the like.[39]

Several anthologies of achievement tests and attitude scales are available.

Norm-Referenced Tests

Lohnes took the position that the results of standardized tests can be used to compare the claims of competing educational programs, since such tests are impartial. They do not measure specific sequences of behavioral objectives for any particular program. Conceptual and operational problems, however, may be encountered when standardized achievement tests are utilized.[40]

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[39] Harvey A. Averch, et al., HOW EFFECTIVE IS SCHOOLING? A CRITICAL REVIEW AND SYNTHESIS OF RESEARCH FINDINGS, (Santa Monica, CA: Rand, 1972), pp. 16-30.

Conceptual problems relate to the generation of incentives, the derivation of normative scores (discussed in Step 5), and cultural bias. Standardized tests may engender perverse incentives by overemphasizing some outcomes at the expense of others. Typically suppressed are outcomes of abstract reasoning and creativity. Cultural bias arises when a test is normed on one population and used to test persons from another population. Bias also occurs when the values of a normative majority population are reflected in test construction and these tests are administered to minority groups which are culturally different. The resulting bias generally will lead to low concept ability scores.

Operational problems center around educational objectives and test content, test validity, and statistical analyses (discussed in Step 5). Standardized tests do not measure all objectives included in each program. While standardized tests cover some objectives, it is unlikely that there ever will be complete agreement between the specific objectives of a program and the content of such tests. For purposes of program evaluation, rather than using a single score averaged across all objective areas, separate scores for each area or objective may be more useful.

Test item generation techniques may lead to tests of low validity. One critic has said, "An item represents the test writer's response to instructional material, and the student's score is thus a function of the test writer and has no known relationship to instructional content."[41] This contention has been refuted. It has been found, "...most items in certain standardized tests of reading and mathematics can, in fact, be keyed to the objectives of a variety of curricula..., to a somewhat lesser extent for study skills...", and ...the least with "program content in the social studies and sciences."[42] If a single test is used to compare curricular alternatives, it should be equally valid for each alternative. Before being utilized as a criteria of effectiveness, a standardized test should be examined relative to each curricula for criterion contamination (elements extraneous to a given curriculum), criterion deficiency (omission of pertinent content), and distortion (greater weighting given to a particular curriculum's content).[43] The relationship between the content of two competing programs and the content of a standardized test is illustrated in Figure 5.5.

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[40] Ibid., pp. 19-26.

Sax has described how a norm-referenced standardized test was constructed, citing the development of the Stanford Achievement Test as an example:

1. Subject matter specialists and teachers determine a test rationale and objectives by listing and prioritizing objectives and assigning weights.

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[41] J. R. Bormuth, ON THE THEORY OF ACHIEVEMENT TEST ITEMS, (Chicago: University of Chicago Press, 1970).

[42] Quilling, "A Data Analysis Approach," p. 57.

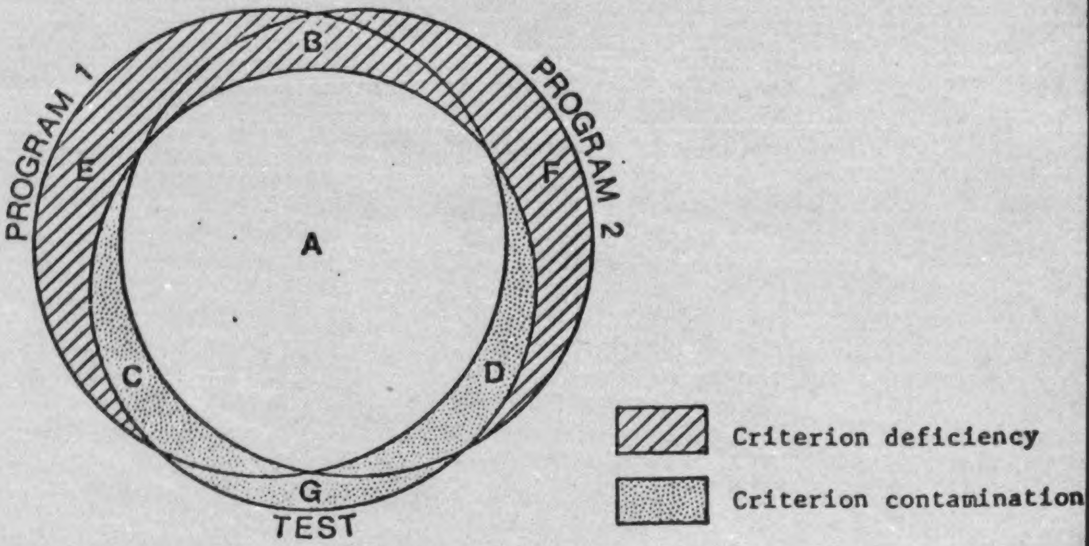
[43] *Ibid.*, pp. 57-9.

2. Subject matter specialists and testing experts write the test items to meet the specified objectives. Adequacy of testing time, ambiguity, relevancy, and difficulty of items is determined by piloting the items on a small number of students.

3. Items are analyzed on a full scale.

4. Final test forms are constructed which comprise item sampling requirements (maximizing content coverage) and administrative requirements.

5. The final form is normed and standardized.[44]



A - Content of test and both programs congruent
B - Content of both programs unrepresented in test
C - Content of test extraneous to Program 2
D - Content of test extraneous to Program 1
E - Content of Program 1 unrepresented in test
F - Content of Program 2 unrepresented in test
G - Content of test extraneous to both programs

Figure 5.5--Schema of a Hypothetical Relationship Between the Content of Two Programs and a Criterion Test

Source: Mary R. Quilling, "A Data Analysis Approach to Evaluating Achievement Outcomes of Instruction," (unpublished Ph.D. dissertation, University of Wisconsin-Madison, 1973), p. 60. (Originally attributed to Cooley and adapted from Lohnes).

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[44] For a complete discussion of standardized tests refer to Gilbert Sax, "The Use of Standardized Tests in Evaluation," in W. James Popham, (ed.) EVALUATION IN EDUCATION (Berkeley, CA: McCutchan, 1974), pp. 255-6.

Criterion-Referenced Tests

Criterion-referenced tests are intended to produce scores related to tasks or performance on specific student knowledge and skills acquisition. Millman[45] compared two types of tests used to make criterion-ferenced inferences, domain-referenced tests (DRT) and differential assessment devices capable of criterion-referenced inferences. "Any test consisting of a random or stratified random sample of items selected from a well-defined set [explicitly stated domain of items or tasks or to an item generating procedure] or class of tasks (a domain) shall be referred to as a DRT."[46] Domain-referenced tests may examine the degree to which program objectives are attained. Due to the nature of the tests, they may be used to reveal effective and ineffective program components. "Criterion-referenced differential assessment devices (CRDAD's) are designed to measure individual or group differences and to yield norm-referenced interpretations."[47] Each item refers to a specified objective or skill. If items can be correctly answered by all students they are deleted from the test for they are poor discriminators. Therefore, DAD's do not estimate the level of functioning.

> It is not reasonable to expect the items retained in a CRDAD to be either random or a representative sample of a defined class of performance tasks.... In general, a test cannot provide scores directly interpretable in terms of a set of performance tasks (that is, interpretable as an estimate of a domain score) and, at the same time, be optimal for

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[45] Jason Millman, "Criterion-Referenced Measurement," in W. James Popham (Ed.), EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, CA: McCutchan, 1974), pp. 311-97.

[46] Ibid., p. 315.

[47] Ibid., p. 319.

> differential assessment.... Items randomly chosen from a specified population of items will not be the same items optimal for discriminating criterion groups.[48]

Consequently, Millman suggested the use of the DRT to maximize pre-instruction, post-instruction differences. At first blush, DAD's may seem the more appropriate of the two, for DRT's might not discriminate pre- and post-treatment gains or produce large differences between treatments. However, DRT's can provide an accurate picture relative to all domains of instruction if randomization of a pool of items from each domain is not violated.

Some[49] have argued that standardized norm-referenced tests are also useful for evaluating programs or program components by rating each item on a test as to its relevance to the curricular objectives and using only those items in calculating test scores. Difficulties may be encountered, however, in attempting to draw out criterion-referenced information from objective based tests. If the purpose of testing is program evaluation, then an assessment of each student's mastery of a domain is not required. Matrix sampling of students and test items may be conducted in order to estimate domain proficiency for a student population.[50]

Quilling[51] pointed out that criterion-referenced tests are as subject to criterion deficiency and distortion as are standardized tests.

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[48] Ibid., p. 319.

[49] Cox and Sterret; Heuer cited in Ibid., p. 387.

[50] Ibid., pp. 387-91; Matrix sampling techniques are explained in Kenneth A. Sirotnik, "Introduction to Matrix Sampling for the Practitioner," in EVALUATION IN EDUCATION: CURRENT APPLICATIONS, W. James Popham, (Ed.), (Berkeley, CA: McCutchan, 1974), pp. 452-527.

[51] Quilling, "Data Analysis Approach," p. 58.

Although item sampling techniques are available to select representative samples of items, a comparison of curriculum and test content is advisable. The face and content validity of items for particular objectives is always suspect.

A question arises as to the usefulness of criterion-referenced tests in comparing student progress with two or more curricula. Little guidance is available from the literature. It has been suggested, however, that objective banks could probably be used to construct criterion-referenced aggregates fair to two or more curricula, although it is unclear how such an aggregate would differ in form from that of a standardized test.[52]

Domain-referenced tests are constructed in the following manner:

1. Defining the item population (domain objectives);
2. Determining domain size and specific facets and elements that should be selected to define the domain;
3. Generating and selecting test items;
4. Establishing a passing standard;
5. Determining a test length; and
6. Evaluating the domain definition and test--reliability and validity.[53]

A comparison of the procedures used to construct norm-referenced and criterion-referenced tests reveals some similarities:

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[52] Ibid., p. 59.

[53] Millman, EVALUATION IN EDUCATION, pp. 327-62.

1. Both tests are concerned with the objectives of instruction.
2. Both types require careful writing and editing.
3. Both require some form of item analysis to select items.
4. Both require standardization in the administering and scoring of items.
5. Both compare the performance of the student with some criterion.[54]

Passing Standard

It may be desirable to establish a minimally acceptable performance standard for curricular alternatives. Such a passing score may be based on a realistic appraisal of probable achievement outcomes using data on the past performance of students with varying ability. Millman described five sources of information which may be useful in order to specify a minimally acceptable level of performance and also explained some procedures for calculating a passing score from those sources.[55]

Specify Evaluative Criteria (Measures) of Cost

Program resource requirements are converted into costs as a function of the analytical process. The nature of the conversion depends upon a specification of the evaluative criteria of costs. The evaluative criteria are determined by one's concept of cost, the nature of the cost model and its structural elements, the program lifecycle included in the evaluation, and distinctions between relevant and irrelevant costs.

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[54] Sax, EVALUATION IN EDUCATION, p. 257.

[55] Jason Millman, "Passing Scores and Test Lengths for Domain-referenced Tests," REVIEW OF EDUCATIONAL RESEARCH, 43 (1973), 205-16.

Concept of Cost

The notion of just what constitutes a "cost" must be confronted for it should determine the nature of any cost model and the subsequent analysis of educational program costs. Apparently, the traditional manner of viewing costs as program expenditures will not suffice. Recent interpretations[56] of educational cost depart from this traditional view. These recent interpretations stem from the basic economic question of how to allocate resources that are in scarce supply. By consuming resources in one manner, those same resources are not available for consumption in alternative ways. In short, costs may be viewed as benefits given up, rather than as benefits received, by choosing to utilize them in one manner rather than another. Benefits foregone (lost) are called "opportunity" costs. By viewing costs thusly, "time" and "space" become important cost considerations. When the time of student and staff personnel are consumed and space is occupied for certain educational purposes, those resources are unavailable for use in a different manner during the specified period of time. Thus, not all costs are easily monetarily estimable.

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[56] J. Alan Thomas, THE PRODUCTIVE SCHOOL: A SYSTEMS ANALYSIS APPROACH TO EDUCATIONAL ADMINISTRATION, (New York: Wiley, 1971), pp. 31-33; and Emil Haller, "Cost Analysis for Educational Program Evaluation," in W. James Popham (Ed.), EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, CA: McCutchan, 1974), p. 401.

Cost Models

A cost model, as any model, should represent those aspects of the real world with the greatest significance to the problem undertaken, in this case, a choice between competing program alternatives. The development of a cost model, according to Dei Rossi, should proceed based upon:

1. The complexity of what is being represented by the model.
2. How frequently the model is to be used
3. The precision with which the real world relationships contained in the model are known
4. The accuracy required to provide adequate information on cost questions for the decisionmaker.[57]

A useful cost model permits "the calculation of cost with a reasonable amount of ease in order to make it time responsive and reduce error" and is "responsive to the key differences characterizing the proposed alternatives."[58]

The development of cost models appears to involve two steps.[59] The first is a decision on the cost element structure. A very detailed cost element structure may allow for a model which is very sensitive to cost analysis. On the other hand, the increased workload may generate the need for automated data processing. The second decision involves the development of cost estimating relationships to transform required present program resources into future costs. Cost estimating relationships are discussed in Step 6.

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[57] J. A. Dei Rossi, "Cost Models and Analysis of Cost," in PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING, p. 115.

[58] Ibid., p. 115.

[59] Ibid., p. 114; Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, p. 118.

Cost Element Structure

The cost element structure provides the framework for distinguishing the combination of resources required of each alternative and for analyzing total costs. Haller identified the elements of one dimension of resource consumption as the "building blocks." They are:

1. Time (staff, students, volunteers, etc.)
2. Space (classrooms, offices, playgrounds, etc.)
3. Equipment (school busses, desks, and microscopes, for example)
4. Supplies (paper, workbooks, and pencils, as well as other materials).[60]

Traditionally, resource expenditure categories in school district budgets are by line-item function or organizational unit as listed in Figure 5.6.

An extension of the traditional cost model by a function or organizational unit approach to include the costs of each object within each functional or organizational category begins to provide a picture of the pattern of program resource consumption. "Object", however, is not necessarily synonymous with "resources." Such is the case with the three dimensional model of financial accounting developed by Lindman shown in Figure 5.7.

---

[60] Haller, EVALUATION IN EDUCATION, p. 419.

Instruction
Pupil Personnel Services
Instructional Media
Research, Planning, Development and
  Evaluation
Board of Education
Data Processing
Facilities Acquisition and Construction
Fiscal Services
Food Services
General Administration
General Services
Information Services
Operation and Maintenance of Plant
Pupil Transportation Services
School Administration
Staff Services
Statistical Services
Community Services

Figure 5.6--Expenditures Accounts in Financial Handbook II, Revised

Source: William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corporation, Association of School Business Officials, 1971), p. 115.

Since one matter of concern in program evaluation is the establishment of a relationship between the combination of resources that comprise programs and program costs, a listing of expenditures only by function or organizational unit is not very useful. Such a listing also disregards the concept of time as a legitimate cost factor. Therefore, a cost element structure should be organized according to the kinds of available resources. This would permit the computations of monetary and nonmonetary costs and thus provide a common format from which to compare the resource configuration associated with each alternative. One such format has been illustrated in Figure 5.3.

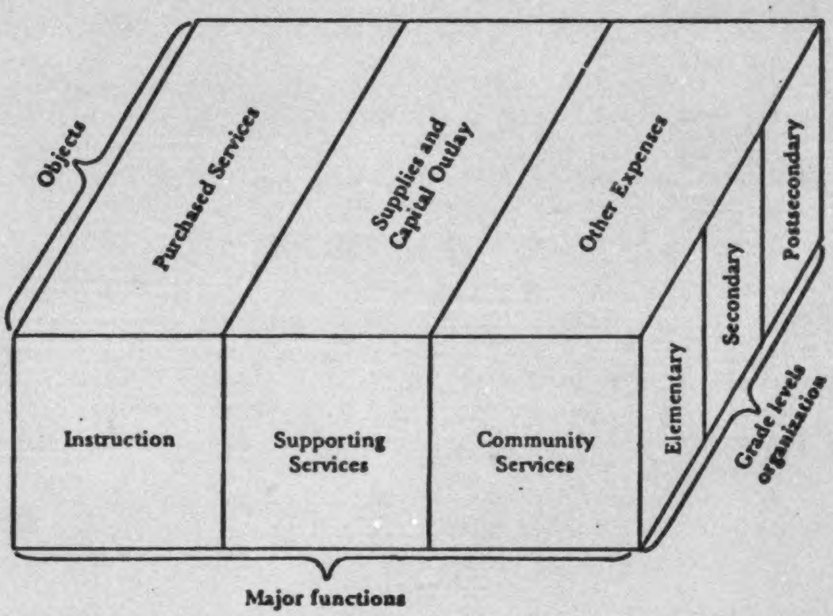
Objects
Purchased Services
Supplies and Capital Outlay
Other Expenses
Postsecondary
Secondary
Elementary
Grade levels organization
Instruction
Supporting Services
Community Services
Major functions

Figure 5.7--Three Dimensional Model of Financial Accounting

Source: E. L. Lindman, cited in Stephen J. Knezevich, PROGRAM BUDGETING (PPBS), (Berkeley, CA: McCutchan, 1973), p. 156.

According to Curtis, the cost element structure should meet the following requirements:

> 1. [It should] specify what general categories of resources are needed.
>
> 2. The resource categories represented by the cost elements should be relatively important in a quantitative sense.
>
> 3. The cost element structure should be no more detailed than required to provide the educational planner with the information needed to compare alternatives.[61]

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[61] Curtis, EDUCATIONAL RESOURCE MANAGEMENT SYSTEM, pp. 114-115.

Life-Cycle of Costs

Program costs may be viewed as a stream of costs beginning with research and development activities, proceduring through implementation activities, and ending with operating activities over the lifetime of the program. Haller has defined those phases:

> Research and development costs--resources required to develop the program to the stage where it can be introduced into the system. For example, the time a science coordinator spends investigating a possible program, money used to hire consultants, and evaluation efforts are appropriately classified as research and development (R&D) costs.
>
> Investment costs--costs necessary to implement the program. Equipment purchases and the costs of running a workshop to train staff are examples of investment costs.
>
> Operating costs--recurring costs required to operate the program over time. Maintenance of equipment, salaries of personnel, and the cost of supplies are examples,
>
> (Note that it is possible to classify some costs in more than one category. For example, the cost of a workshop to train personnel to operate a program might be considered as either R&D or investment. Where you place such costs is not usually important. What is important is that you not omit them.)[62]

Haller illustrated the relative magnitude of categorical costs over the life span of a program (see Figure 5.8). Notice that R&D, investment, and operating costs overlap each other during a program's life cycle.

Haggart and Curtis[63] would divide program life-cycle costs into two categories, acquisition and operational. Acquisition is referred to as initial, investment, or capital cost. According to their description, research and development activities are absorbed within the components of acquisition, whereas Haller viewed R&D activities as separate from investment costs.

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[62] Haller, EVALUATION IN EDUCATION, p. 420.

[63] Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, p. 116; Haggart, "Program Cost Analysis in Educational Planning," pp. 9-11.

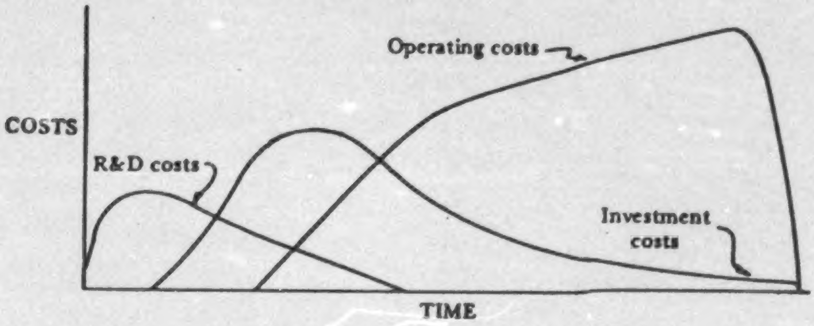

Figure 5.8--Relationship Between Costs and The Life Cycle of a Program

Source: Emil Haller, "Cost Analysis for Educational Program Evaluation," in W. James Popham (Ed.), EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, CA: McCutchan, 1974), p. 421. (Adapted from Fisher).

The major components of Curtis' acquisition and operational cost element structures (see Figure 5.9) confuse both functions (e.g., in-service training) and resources (e.g., equipment). Haggart's structure is similar. (See Figure 5.3).

Perhaps, then, an appropriate cost element structure is not available and the "building blocks" of costs take on more meaning as basic inputs from which to develop such a structure. (See Figure 5.10).

Level I	Level II
Acquisition Cost	Acquisition Cost
Program Implementation	Program Implementation
Equipment	Equipment
	Program-related
	Student-related
Materials	Materials
	Program-related
	Student-related
Pre-service Training	Pre-service Training
Facilities (Space)	Facilities (Space)
	Installation
Operational Cost	Operational Cost
Staff	Salaries
	Teachers
	Paraprofessionals
	Specialists
	Other
In-service Training	In-service Training
Materials & Supplies	Materials & Supplies
	Program-related
	Student-related
Equipment	Equipment
	Replacement
	Maintenance
Other Support Costs	Facilities O&M
	Contracted Services
	Media Services
	Transportation

Figure 5.9--Cost Element Structure

Source: William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corporation, Association of School Business Officials, 1971), p. 116.

R&D costs	Investment costs	Operating costs
1.1 Time	2.1 Time	3.1 Time
1.2 Space	2.2 Space	3.2 Space
1.3 Equipment	2.3 Equipment	3.3 Equipment
1.4 Supplies	2.4 Supplies	3.4 Supplies

Figure 5.10--Basic "Building Block" Input Structure

Source: Emil Haller, "Cost Analysis for Educational Program Evaluation," in EVALUATION IN EDUCATION: CURRENT APPLICATIONS, in W. James Popham (Ed.), (Berkeley, CA: McCutchan, 1974), p. 422. (Adapted from Fisher).

Cost Dichotomies

Although all costs are opportunity costs in a strict sense, they may be divided into several different dichotomies:

1. Direct or indirect
2. Social or private
3. Monetary or nonmonetary
4. Sunk or incremental
5. Fixed or variable
6. Recurring or nonrecurring
7. External or internal

These categories are useful in distinguishing relevant from irrelevant costs when conducting analyses. Identifying and calculating the cost implications for every program would be exhausting and inefficient. Relevant costs are those that bear on the nature of the decision as a consequence of the cost analysis. Thomas[64] distinguished between direct and indirect, social and private, and monetary and nonmonetary costs.

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[64] Thomas, THE PRODUCTIVE SCHOOL, pp. 33-35.

Direct or Indirect. A dollar amount may be placed on both direct and indirect costs. Direct costs, however, entail an expenditure of money, whereas indirect costs do not entail an outright expenditure. Direct costs include salaries and purchases. Indirect costs must be valued in terms of foregone opportunities. They include students' loss of earnings while engaged in education, depreciation and obsolescence of facilities, imputed interest on invested capital, and property and sales tax exemptions.

Social or Private. Private costs of education are incurred by students and their families. They may be direct outlays of monies or may be calculated as indirect costs. Social costs include all private costs, but also represent costs incurred by the wider society, e.g., taxes to support public education.

Monetary or Nonmonetary. Monetary costs are calculated in dollars and may be direct or indirect, social or private. Nonmonetary costs include all costs which cannot be calculated in dollar terms, for example, the time of students and teachers.

Sunk or Incremental. Haller[65] has provided useful distinctions between sunk and incremental, fixed and variable, recurring and nonrecurring, and external and internal costs. Sunk costs are those which have been incurred as a consequence of past resource consumption decisions not bearing upon a program evaluation (e.g., costs to construct a facility in the past which now houses a new program). Incremental costs are those that occur in the future as a result of decisions related to program alternatives (e.g., program costs incurred due to a facility's use).

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[65] Haller, EVALUATION IN EDUCATION, pp. 424-37.

Fixed or Variable. Costs that are not affected by a change in a program's scope or size are fixed "within fairly broad limits," such as administrative salaries, maintenance, and overhead. Variable costs are those which are immediately affected by program decisions, for example, books and supplies. Small changes in typically labelled variable costs may not engender additional resource needs. Similarly, fixed costs become variable at certain extremes. Joint costs are those fixed costs which are shared among programs. They are costs generally shared on a pro rata basis.

Recurring or Nonrecurring. A cost is either recurring or nonrecurring depending on that point in time when a resource consumption decision is made. Nonrecurring costs are those incurred only once during a specified period of time, e.g., inservice training of teachers, whereas recurring costs are incurred repeatedly during a specified period of time, e.g., staff salaries.

Bickner noted that the distinctions between sunk and incremental, fixed and variable, and recurring and nonrecurring costs

> ... are related to ...the time, the scope, and the horizon of the decision being analyzed. Thus, the costs of continuing and educational program (and the distinction between sunk and incremental costs) depends upon the point in time of the decision. The costs of expanding or contracting a program (and the distinction between fixed and variable costs) depends upon the proposed change in the scope of the program.

> Finally, the cost of extending a program, as well as the distinction between recurring and nonrecurring costs, depends upon the initial and revised termination dates or the horizon of the program.[66]

External or Internal. The final distinction is between external and internal costs. The distinction between these terms rests upon the relationship of the decisionmaker's position in the educational system's hierarchy to the programs being evaluated. Program costs are external if "they are borne by someone or some organization other than the evaluator's client. Conversely, internal costs are borne directly by the decisionmaker's organization."[67] When the salaries of teachers are not determined by program administrators, they are external costs. The utilization of teacher time is, for the most part, within a program administrator's jurisdiction. Thus, it is an internal cost. All internal costs of a program must be included in the analysis. The inclusion of external costs, reported separately, depends upon whether or not they are of concern to a decisionmaker.

Determine the Cost of Each Alternative

From the literature on the costing out of educational programs for comparison purposes an exhaustive list of areas of concern can be highlighted. The following areas of concern can be summarized as dealing with establishing a cost methodology, standardizing cost data, accounting for present and future costs and identifying those factors which influence cost variations.

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[66] R. E. Bickner, cited in Ibid., p. 427.

[67] Haller, EVALUATION IN EDUCATION, p. 427.

Purpose of Cost Analysis

Thomas emphasized the importance of cost analysis in educational decisionmaking.

> 1. At one level, cost data are primarily descriptive. Information about the cost of building and operating a school, of providing a course in vocational agriculture, or of providing special training for the chronically unemployed is important for comparative and historical purposes.
>
> 2. More important, cost data reveal what is given up in terms of other alternatives for which a given set of resources might be used...cost analysis is therefore an essential element in internal decision making, since a decision or choice from among alternatives means giving up certain options; costs may be regarded as measures of what is foregone or given up. The benefits as well as the costs of the various alternatives that are considered comprises, in both intuitive and rigorous terms, the proper basis for making decisions.
>
> 3. The careful analysis and reporting of cost data provides a means of control over the internal operation of educational systems. Such control is necessary to ensure wise and proper use of funds.
>
> 4. Finally, unit cost data provide an important input into certain kinds of research. Operational research, which may be defined as the scientific study of management, requires cost data.[68]

Steps in Cost Analysis

Both Pearson and Haller[69] have listed procedures involved in cost analysis. Pearson envisioned four steps: identify resource restraints;

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[68] Thomas, PRODUCTIVE SCHOOL, pp. 39-40.

[69] Pearson, "A Study of Cost-Effectiveness Analysis," pp. 51-52; Haller, EVALUATION IN EDUCATION, pp. 413-437.

calculate costs; identify possible cost variances; and verify completeness. Haller's steps included describing decision alternatives and developing an activities list, developing an input structure, determining the types of costs to be considered (that is, relevant versus irrelevant costs), measuring and projecting costs, and comparing the cost of alternatives. Haller recognized the important link between cost categories and program descriptions in his first step. To Haller, preliminary descriptions involve three distinct but interrelated phases: describing the decision to be made in terms of alternative courses of action, ascertaining the objectives to be attained from each alternative, and developing as accurate and as complete a description as possible of the activities necessary to attain each objectives. Section 2 in this chapter entitled "Distinguish the Alternative Programs," essentially dealt with this procedure. The development of an input structure or cost categories was dealt with in Section 4. Resource constraints result from the manner in which data are aggregated. Costs should be broken down into units small enough to permit useful analysis. The relevancy of certain types of costs, as discussed in Section 4, rests upon the nature of the decision being taken. It is helpful to measure and project costs on an appropriate time base, e.g., for each successive year, as well as in total. The total alternative costs over the life span of a program may be affordable, but the initial outlay or short range costs for a program may not be affordable. The calculation of various costs will be considered later in this section. Each cost estimate is likely to have a varying degree of specificity and completeness. This results in cost variances within similar cost categories of each alternative.

The delineation of unknown factors assists in analyzing the comparability of cost data. The availability of appropriate, accurate, and timely cost estimates will affect the completeness of the cost data. Total, average, and marginal costs may be calculated and used in comparing alternatives.

Factors Which Influence and Govern Costs

In cost-effectiveness analysis, Hartung stressed the importance of examining costs at the time they occur for "there is an inherent and distinct cost advantage as to the chronology of expenditures"-- an advantage based upon the "present worth of future dollars."[70] Certain influences may increase the future cost of an item while others may make money increase in value. Borrowing, inflation, and technological risk at a time when programs require additional development will work to escalate costs. On the other hand, monetary growth is achieved by deflation, tax revenue increases which raise the value of the expenditure dollar, and the investment of principal which causes surplus and less need for borrowing.

Whereas the above factors are macroeconomic and affect the availability of the dollar, some local conditions, as pointed out by Merewitz and Sosnick,[67] will govern costs: size and performance characteristics; rate and cumulative number of units procurred; and procurement practices.

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[70] Walter G. Hartung, AN INDEX FOR USE IN THE SELECTION OF COST EFFECTIVE SYSTEMS, AD 678 514, (Springfiedl, VA: Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, 1968), p. 4.

The cost for each unit or product tends to be closely related to the characteristics of the product. By historically examining product cost trends, future product costs can be estimated. Cost savings can be achieved by increasing the rate of output (economies of scale). Certain factors such as size of facilities affect the number of units of output which can be produced during a period of time. Until this capacity is reached, the rate of output may be increased without increasing capital stock or fixed costs of certain resources. Costs are spread over more units of output, thereby achieving lower unit costs. In certain manufacturing operations, it has been found that the more frequently a function is performed by an operator the less direct labor time is required to produce a unit of output. This result is attributed to learning. Thus, average cost of the output declines as more cumulative output is produced. Within the framework of education, however, this increased productivity may not be realized due to several constraints--not all outputs are the same and, in traditionally operated programs, the students' movement out of each level of education into the next proceeds at a near constant rate. Programs of continuous progress, however, in which movement between levels of education is not constant, may operate according to the cumulative output-teacher learning curve. Resource procurement practices will influence the cost per unit of input. The quantity and quality of each purchased input, nature of the purchasing

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[71] Leonard Merewitz and Stephen Sosnick, THE BUDGET'S NEW CLOTHES: A CRITIQUE OF PLANNING-PROGRAMMING-BUDGETING AND BENEFIT-COST ANALYSIS, (Chicago: Markham, 1971), pp. 225-36.

contract (blank-check vs. strict firm-fixed-price contract), and the existence of competitive bidding are reflected in variable costs.

Cost Record and Retrieval

Since the availability of appropriate, accurate, and timely cost estimates are essential to the validity of cost analysis, the manner in which data are recorded and retrieved is critical. Kiesling[72] has stressed the need for accounting techniques in systems analysis.

> Program accounting means the recording and classifying of resource expenditures around one or more outcomes, not a new or regrouped set of activities devoid of measurable objectives.[73]
>
> Criteria which must be satisfied include:
>
> 1. Programs designed at the very beginning;
> 2. Expenditures clustered around activities (functions), but then activities must be aggregated around a program and its objectives; and
> 3. A multi-year time frame for recording fiscal data.[74]

A system of coding expenditures must be devised for such a programmatic format. Figure 5.11 illustrates such a coding system. Cost accounting is "that branch of accounting concerned with searching out and reporting all elements of the cost incurred in executing a specific activity or unit or work."[75]

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[72] Herbert J. Kiesling, "On the Economic Analysis of Educational Technology," (unpublished manuscript, Indiana University, Bloomington, Indiana, no date), p. 7.

[73] Knezevich, PROGRAM BUDGETING, p. 157.

[74] Ibid., p. 157.

[75] Knezevich and Fowlkes, cited in Ibid., p. 159.

Code section	A	B	C	D	E	F	G	H
Section title	Fund	Type of Account	Organizational unit	Area of responsibility	Subject area	Course	Activity	Object
Number of digits used	XX	X	XXX	XXX	XX	XXX	XX	XX

Figure 5.11--Coding of Expenditures

Source: J. E. Mitchell cited in S. J. Knezevich, PROGRAM BUDGETING (PPBS), (Berkeley, CA: McCutchan, 1973), p. 160.

In the case of large cost models, calculations may be very time consuming, necessitating the use of automated data systems. Computer-based information systems assist in the quick retrieval of accurate information.[76] Dei Rossi[77] would combine automated and nonautomated calculations, since there are aspects of cost accounting which require "human discretion."

Nature of the Cost Data

It was noted earlier that the concept of cost has taken on a new meaning. Expenditure is not synonymous with cost; it is a component of cost. In the broadened definition of cost, all resource consumption, including the consumption of time and space, must be recognized.

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[76] Ibid., p. 159.

[77] Dei Rossi, PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING, pp. 115-116.

Therefore, all costs cannot be recorded in dollar terms and the nature of cost data has changed accordingly. Bickner recognized four kinds of costs in program evaluations:

1. Costs that can be measured in dollar expenditures;
2. Costs that can be reasonably measured in dollars, though they are not reflected in expenditures;
3. Costs that are quantifiable; and
4. Costs that are not quantifiable.[78]

Salaries and purchases of supplies and equipment can be accounted for in dollar expenditures; depreciation and property tax exemptions serve as examples of the second category. The cost of space is often, but not necessarily, accounted for in dollar terms. The time commitment of students is quantifiable. Costs are incurred which cannot readily be measured. These are often associated with the side effects of a program on, for example, other programs, staff morale, or public opinion. On the other hand, Miller and Rath asserted that cost should be measured in the following ways:

1. matter-energy, information, and time;
2. human effort (student time and effort, teacher time and effort, and administrative or technician time and effort); and
3. monetary costs (short run and long run capital and operating activities).[79]

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[78] Bickner cited in Haller, EVALUATION IN EDUCATION, p. 430.

[79] J. G. Miller and G. J. Rath cited in Pearson, "A Study of Cost-Effectiveness Analysis," p. 51.

In the above structure, however, the distinctions between (1) and (2) and (1) and (3) are not clear. The resources consumed in Category 1 may be measured in time and/or money.

Crosswalk

"A 'crosswalk' is the expression of the relationship between a program budget and a traditional budget."[80] The relationship is displayed in a tabular array, whereby the program budget cost categories occupy the rows and the traditional budget cost categories occupy the columns (see Figure 5.12). As a result of transforming anticipated costs from a traditional to a program budget format, the description of potential resource consumption by program is achieved. This transformation is needed only for expenditure data in program evaluations where a standard program budgeting format is not in use. It should be noted that, although a transformation is made to the program budget format, the program budget may not satisfy one's desire to examine costs by resource categories. This is the case in Figure 5.12.

Dei Rossi[81] distinguished traditional and program budgets by content, structure, and time horizon. With respect to content, a program budget contains a complete description of required resources which are keyed to program design and operation. A traditional budget usually provides current planned operating resource expenditures. With respect

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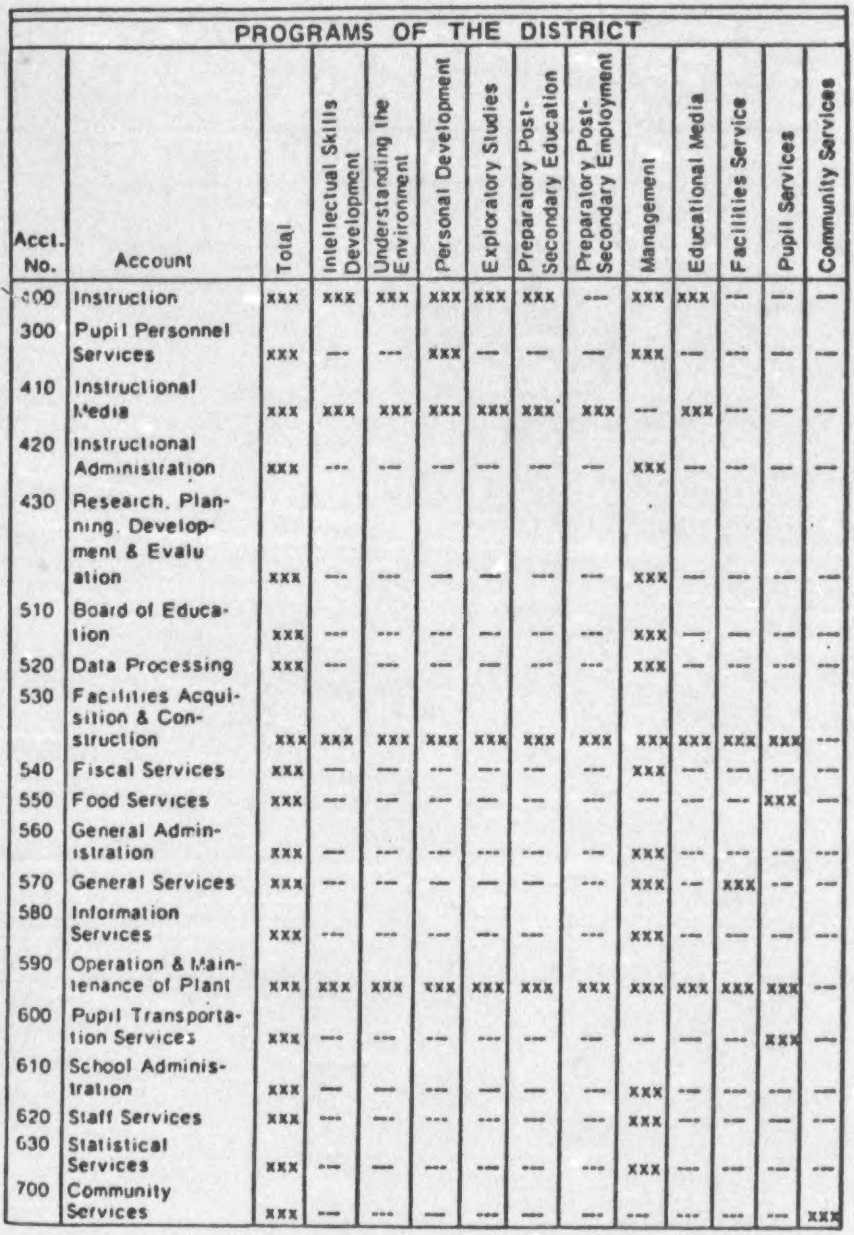
[80] Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, p. 122.

[81] Dei Rossi, "The Program Budget and the Traditional Budget," in PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING, pp. 54-58.



PROGRAMS OF THE DISTRICT													
Acct. No.	Account	Total	Intellectual Skills Development	Understanding the Environment	Personal Development	Exploratory Studies	Preparatory Post-Secondary Education	Preparatory Post-Secondary Employment	Management	Educational Media	Facilities Service	Pupil Services	Community Services
400	Instruction	xxx	xxx	xxx	xxx	xxx	xxx	---	xxx	xxx	---	---	---
300	Pupil Personnel Services	xxx	---	---	xxx	---	---	---	xxx	---	---	---	---
410	Instructional Media	xxx	xxx	xxx	xxx	xxx	xxx	xxx	---	xxx	---	---	---
420	Instructional Administration	xxx	---	---	---	---	---	---	xxx	---	---	---	---
430	Research, Planning, Development & Evaluation	xxx	---	---	---	---	---	---	xxx	---	---	---	---
510	Board of Education	xxx	---	---	---	---	---	---	xxx	---	---	---	---
520	Data Processing	xxx	---	---	---	---	---	---	xxx	---	---	---	---
530	Facilities Acquisition & Construction	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	---
540	Fiscal Services	xxx	---	---	---	---	---	---	xxx	---	---	---	---
550	Food Services	xxx	---	---	---	---	---	---	---	---	---	xxx	---
560	General Administration	xxx	---	---	---	---	---	---	xxx	---	---	---	---
570	General Services	xxx	---	---	---	---	---	---	xxx	---	xxx	---	---
580	Information Services	xxx	---	---	---	---	---	---	xxx	---	---	---	---
590	Operation & Maintenance of Plant	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	---
600	Pupil Transportation Services	xxx	---	---	---	---	---	---	---	---	---	xxx	---
610	School Administration	xxx	---	---	---	---	---	---	xxx	---	---	---	---
620	Staff Services	xxx	---	---	---	---	---	---	xxx	---	---	---	---
630	Statistical Services	xxx	---	---	---	---	---	---	xxx	---	---	---	---
700	Community Services	xxx	---	---	---	---	---	---	---	---	---	---	xxx

Figure 5.12--Crosswalk Example

Source: William H. Curtis, EDUCATIONAL RESOURCES MANAGEMENT SYSTEM, (Chicago: Research Corp., Association of School Business Officials, 1971), p. 127.

to structure, a program budget is organized according to the objectives of the program (or its elements) and the resource requirements and cost activities involved in the program (elements). Traditional budget items are primarily, but not exclusively, by organizational units and functions. Program budgets generally are projected over a longer period of time than are traditional budgets. Traditional budgets typically operate over a one-year time frame while program budgets will project financial impact over several years. This allows for a comparison of costs in both the initial stages and the later stages of a program's life.

Unit Cost Basis for Resources

To compare costs between programs, a standard unit of measure must be adopted for each input. The cost basis could be done by student, program, unit, or direct service charge[82] (see Figure 5.13). The per unit basis refers to units of physical proximity such as classrooms, resource centers, laboratories, teachers, etc. A direct service charge reflects the total charges for a service performed either within the school district or by an outside source. A combination of units may be used for each resource category. In some cases, program costs are independent (fixed) of the number of students or size of facilities which house students. Direct service charges, however, may be "by program" if specific services are provided only to a specific program or services are indirectly charged to programs on an allocation (e.g., prorated) basis. Haggart provided a table which relates cost categories to standard units of measure (see Figure 5.13).

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[82] Haggart, "Program Cost Analysis in Educational Planning," pp. 11-12.

	Cost Basis			
Categories	Student	Program	Unit	Service
Acquisition Cost				
Design of program		x		
Development of materials		x		
Evaluation design		x		
Program implementation		x		
Equipment				
Program-related		x	x	
Student-related	x			
Materials				
Program-related		x	x	
Student-related	x			x
Pre-service training		x		x
Facilities	x			
Installation			x	
Operational Cost				
Program direction		x		
Evaluation	x	x		
Management support		x		
Salaries				
Teachers	x			
Paraprofessionals	x			
Specialists	x	x		
Other	x	x		
In-service training		x		x
Materials and supplies				
Program-related		x	x	
Student-related	x			
Equipment				
Replacement			x	
Maintenance			x	
Facilities O&M				x
Contracted services	x			x
Media services	x			x
Transportation	x			x

Figure 5.13--Unit Cost Basis for Inputs

Source: Sue A. Haggart, "Program Cost Analysis in Educational Planning," (paper presented at the National Conference on Performance Contracting in Education, Washington, D.C., December 9 and 10, 1971), p. 11.

Cost differences may result from factors external to the resource requirements of particular programs. Quality of service and prices paid per unit of resources are two such external factors. In addition, total cost differences may result from different "output mixes" as cautioned by Thomas.[83] Such differences must be noted and explained in any comparative cost analysis. Output mix is the product of the input cost per student hour and enrollment. Gross units of time, for example, school years and school days, vary in length. Specific programs also vary in length, therefore, Thomas preferred "cost per student hour" for each specific service including salaries, space, equipment, and materials. Program enrollment also affects the price per unit of resources in a way referred by Thomas[84] as the factor of "indivisibilities." Inputs are consumed in discrete units. They are not infinitely divisible. Thus as inputs are added, if they are not used to the maximum extent possible the cost per unit will increase sharply. As resources such as space, personnel, or equipment are used more intensively, the cost per student hour decreases.

Knezevich[85] identified the method of prorating expenditures as an aspect of unit cost analysis. Proration should be standardized for expenditures that can be assigned to more than one cost category. Methods of proration are based upon such factors as time, hour, consumption, mileage, and number of pupils.

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[83] Thomas, PRODUCTIVE SCHOOL, pp. 42-3.

[84] Ibid., pp. 52-3.

[85] Knezevich, PROGRAM BUDGETING, p. 162.

Cost Components of Specific Resources

Methods have been proposed for estimating the costs incurred in utilizing staff, students, facilities (space), equipment, and materials and supplies.

Staff Personnel

To calculate staff costs, data on the number and type of instructional and support staff positions, time spent on each activity, and salary are required.[86] Time includes preparation for classes, grading papers, setting up experiments, etc.[87] The administrative time spent on educational program services should be prorated among those programs.[88]

Two variables exert great influence on salaries--experience and level of training. These two variables can make the cost of the same number and type personnel much greater in one school distrcit than in another. Salary schedules are used to project future costs. Therefore, consideration must be given to the movement of staff through the schedule, changes in the schedule, attrition, and staff replacement characteristics. Fringe benefits also comprise a significant cost category. They include, for example, retirement, medical and dental insurance, and accident insurance. It should be recognized that changes in fringe benefits occur in a different fashion than do changes in salary schedules.[89]

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[86] Haggart, "Program Cost Analysis for Educational Planning," p. 19.

[87] Thomas, PRODUCTIVE SCHOOL, p. 43.

[88] Ibid., pp. 43-4.

[89] Haller, EVALUATION IN EDUCATION, pp. 432-3.

If personnel may be assigned to any one of several activities, then assigning a teacher, for example, to one activity rather than another requires that one consider the opportunity costs associated with the alternative activities which are foregone. Although these costs can be described, they generally are difficult to quantify.

Student Personnel

Costs are measured by student time. Student time may be translated into dollars for students enrolled in programs at the secondary school level and the college level, or in adult vocational education. The object here is to estimate the foregone earnings of students who would otherwise be in the labor force. Schultz estimated that 60 percent of school costs in high school and college consiste of earnings foregone[90] (see Figure 5.14).

United States, 1956 (Dollars)	School Costs	Earnings Foregone	Total	Earnings Foregone as Percentage of Total Costs
8 years elementary	280	0	280	0
4 years high school	568	852	1420	60
4 years college or university	1353	1947	3300	59

Figure 5.14--School Costs, Earnings Foregone, and Total Costs of Schooling per Student per Year in the United States

Source: Theodore W. Schultz, THE ECONOMIC VALUE OF EDUCATION, (New York: Columbia University Press, 1963), p. 29.

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[90] Theodore W. Schultz, THE ECONOMIC VALUE OF EDUCATION, (New York: Columbia University Press, 1963), p. 29.

For students in the lower grades, time may be measured in student instructional hours obligated by a program. Haller[91] suggested that student instructional time spent in a classroom may not represent the total instructional time involved in a given program. Students also may be expected to spend time outside of the classroom as part of an educational program.

Thomas[92] suggested that "foregone learning", a concept developed by Bowman, is an important dimension of student time. It implies that, while a student is engaged in one learning activity, he cannot participate in another activity or, at least, his participation in another activity is limited. The consequences of foregone learning may not be quantifiable, but should be recognized by decision-makers.

Facilities

The concept of space uitlization is most appropriate when estimating the program cost of facilities. A standard unit of measure is used to estimate space utilization. A significant variable will be the amount of time a given space is used. If a per student-hour cost is preferred, then the number of students using the space becomes an important variable. The total dollar cost of space is calculated by summing the cost of each of its components:

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[91] Haller, EVALUATION IN EDUCATION, p. 431.

[92] Thomas, PRODUCTIVE SCHOOL, p. 32.

1. Interest on debentures (unpaid debt);
2. Imputed (foregone) interest on equity;
3. Depreciation (annual decrease in value);
4. Maintenance; and
5. Overhead (light, power, and heat).[93]

Equipment

Haller[94] suggested that where substantial equipment costs are incurred, these should be prorated to programs over their expected life span. He added that "rule-of-thumb" cost estimates are appropriate in the case of equipment. The costs can be calculted as follows:

1. Imputed interest;
2. Maintenance; and
3. Depreciation.[95]

Materials and Supplies

Two methods are proposed for costing materials and supplies. Haller suggested a simplistic method of approximating costs for materials and supplies--simply "dividing the current budget figures for materials and supplies by the number of pupils to determine an average cost per pupil served by a program.[96] Crane and Abt[97] suggested the following method for calculating annual costs of materials and equipment:

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[93] Ibid., p. 45.

[94] Haller, EVALUATION IN EDUCATION, p. 434.

[95] Thomas, PRODUCTIVE SCHOOL, p. 45.

[96] Haller, EVALUATION IN EDUCATION, p. 434.

[97] Peter Crane and Clark C. Abt, "A Model for Curriculum Evaluation," EDUCATIONAL TECHNOLOGY, 9 (October, 1969), p. 23.

(1) $$\frac{\text{Number of units x price per unit}}{\text{life span (years)}} = \text{annual cost of each different unit of purchase}$$

(2) $$\frac{\text{Teacher training costs over ten year period (which considers turnover rate) divided by ten}}{\text{standard measurable unit, i.e., students, classrooms, programs, etc.}} = \text{annual training cost to use materials and equipment}$$

Cost Analysis of Educational Media Systems

Sovereign[98] proposed an analytical structure unique to educational media systems. He classified cost elements into production, distribution, and reception functions and defined each function as follows:

> Production: Production costs are those incurred in the inception, creation, development, and preparation of the instructional content. The acquisition of media programs and its related costs, such as selection and order handling, are also classified as production costs. For a media system, these costs must include the cost of curriculum design, the use and development of research and evaluation teams, media specialists, facilities, and all the myriad of inputs necessary to produce a successful learning experience for the student. Specific examples are script writing and recording of programs for radio and television.
>
> Distribution: Distribution costs are those incurred in changing or copying the material from its original form, if necessary, and sending it to a point at which it will be reconverted to a usable form for the student. Usually, the transmitted material is not in a form which is immediately useful to the student. Examples are duplicating original tape and broadcasting for television, duplicating and mailing film from a processing center to a school, or duplicating and playing tape and transmitting to headphones in language laboratories.

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[98] Michael G. Sovereign, COSTS OF EDUCATIONAL MEDIA SYSTEMS, (Stanford, CA: ERIC Clearinghouse on Educational Media and Technology, Institute for Communication Research, Stanford University, 1969), pp. 7-10.

> Reception: Reception costs are those incurred in changing the form and presenting the distributed material so that it is useful to the student. Examples are antennas, TV sets, film projectors, screens, headphones, and carrels.

Sovereign calculated the equivalent annual cost of alternative media systems for purposes of cost comparisons, using a procedure whereby capital costs are amortized over the life of the investment and added with interest to the average annual operating cost. This procedure provides a uniform annual estimate. Standard financial tables are used to obtain a capital recovery factor for a particular interest rate and life span of the purchase. The product of the capital cost and capital recovery factor is added to the annual operating cost. The result is the equivalent annual cost.

Cost Analysis of Program Implementation

Boardman and Hudson[99] designed an analytical cost structure to obtain the amount of expenditure required to implement a program of Individually Guided Education (IGE) and cost changes caused by the implementation of IGE. The analysis requires an explanation or description for cost item dollar expenditures:

1. Staff Development (e.g., reimbursement for staff, substitute teachers, travel, materials, facilities, consultants, and overhead)
    a. Clue-in (a one-day awareness conference)
    b. Overview (a follow-up presentation)

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[99] G. R. Boardman and C. Cale Hudson, DEVELOPMENT OF A COST ANALYSIS MODEL WHICH SCHOOLS MAY USE TO DETERMINE BUDGET NEEDS FOR IMPLEMENTING INDIVIDUALLY GUIDED EDUCATION (IGE), /I/D/E/A/ Research Grant, (Lincoln, NE: Teachers College, University of Nebraska, 1973), pp. 88-102. See also Nancy A. Evers, IGE/MUS-E FIRST YEAR IMPLEMENTATION COST SURVEY, Technical Report No. 256, (Madison, WI: Wisconsin Research and Development Center for Cognitive Learning, 1973), pp. 54-67.

c. Clinical workshop (an inservice workshop of weeklong duration)

d. Expenditures (a through c) that are in addition to normal pre-IGE cost requirements and those additional costs anticipated to be ongoing

e. Teacher visitation to other schools (include cost of substitute teachers, travel and lodging, etc.)

f. Consultants

g. Materials (e.g., films, tapes, guides, professional books, etc., that deal directly with aiding the staff in the concepts and process of IGE)

h. Other types of workshops (school district's workshop costs. The costs of district staff employed solely for the IGE program may be prorated)

i. Other (costs for inservice staff development not covered in the above categories)

j. Expenditures (e through i) in addition to normal pre-IGE cost requirements and those additional costs anticipated to be ongoing

2. Instructional Personnel (e.g., amount of cost changes for unit leaders, regular staff, salary of instructional and clerical aides, substitute teachers and released time for planning attributable to IGE.)

   a. Professional staff (generally cost changes caused by alterations in the number of staff, educational requirements, or extra pay for unit leaders)

   b. Instructional aides who work directly with teachers in IGE instruction

   c. Clerical aides who directly assist teachers with records and other housekeeping type tasks,

   d. Substitute teachers (distinguish expenditures to replace regular teacher due to illness from those due to planning time)

   e. Trade-offs, i.e., reducing budget categories in order to increase others.

3. Instructional Materials and Supplies (actual costs attributable to the IGE program)

   a. Classroom materials and supplies assigned for use in the classroom and under the direct control of the teacher

   b. Resource center/library to included costs of all A.V. materials, books, films, transparencies, periodicals, etc.

   c. Other (e.g., jointly shared materials and supplies)

   d. Expenditures (a through c) that are in addition to normal pre-IGE cost requirements and those additional costs anticipated to be ongoing

4. Administration (e.g., bookkeeping, program evaluation and administrative personnel)

   a. Secretary-clerk (cost changes to support administration which are attributable to the IGE program)

   b. Program evaluation (actual expenditures attributable to the IGE program)

   c. Costs in addition to normal pre-IGE cost requirements and those additional costs anticipated to be ongoing

   d. Administrators (cost changes attributable to the IGE program excluding the IGE facilitator)

   e. Other cost changes attributable to the IGE program

5. Public Relations (actual expenditures for new activities such as newsletters, coffees, visitations, etc.)

   a. Central office

   b. Schools

   c. Costs in addition to normal pre-IGE budget and those additional costs anticipate to be ongoing

6. Capital Outlay and Maintenance (actual expenditures, for example, space modifications, carpeting, lighting, and instructional equipment) which would not have been incurred had it not been for accommodating the IGE program)

    a. Space modifications
    b. Resource center/library
    c. Instructional equipment
    d. Maintenance
    e. Other
    f. Expenditure (a through e) in addition to normal pre-IGE cost requirements and those additional costs anticipated to be ongoing

7. League Participation (e.g., costs of facilitator, including such items as salary, office space, rent, and materials and supplies, prorated on the basis of percent of time spent facilitating)

   Distinguish temporary from permanent costs

Comparable Replication Cost

A comparison of program costs between districts will reflect not only differences between programs but also differences in unit purchase prices. Differences in unit prices will contaminate the comparisons. Resources previously purchased or assets inherited from discontinued programs are counted as actual costs. A standard price for all actually or potentially consumed resources is used to calculate the comparable replication cost. Costs then are comparable because variations in the price per unit of resource are adjusted. Figure 5.15 is an example of standard resource costs and factors for specific resources.

Cost Estimating Relationships

Cost estimating relationships (CERs) convert resource characteristics of program requirements into costs--the unit cost of each resource or the number of required units. CERs serve as the basis for developing

Facilities	
Remodeling (including carpeting, airconditioning, etc.)	$ 3,000/center
Furnishings (including carrels)	$ 2,000/center
Equipment	
Replacement	10%
Maintenance (depends on estimate of reliability based on complexity)	10% or 20%
Materials	
Attrition from use, theft	10%
Consumables	$ 10/student
Salaries (including fringe benefits)	
Teachers	$12,000/year
Paraprofessionals	$ 5,000/year
Specialists	$12,000/year
Program directors	$15,000/year
General support	$10,000/year
General administrative	$12,000/year
Consultants	$ 100/day

Figure 5.15--Standard Resource Costs and Factors

Source: Sue A. Haggart, "Program Cost Analysis in Educational Planning," (paper presented at the National Conference on Performance Contracting in Education, Washington, D.C., December 9 and 10, 1971), p. 73.

program cost estimates. Dei Rossi listed three steps to determine program costs using CERs:

1. Appropriate units of measurement for each of the types of required resources must be determined [example: square feet] [see "Unit Cost Basis for Resources"];
2. CERs indicating the cost per unit as a function of the characteristics of the unit must be developed [example: square feet per student];
3. Relationships indicating the required number of units of each resource must be established [example: 5 square feet per student].[100]

CERs may be used to project future costs:[101]

Future cost per unit = present cost per unit x $(1+i)^t$,
where i = percentage rate of cost increase and t =
number of years of projection (current year = 0)

Total unit costs are estimated by multiplying the future cost/unit by the number of required units. The number of units required may be estimated by examining past records or legal requirements. Dei Rossi,[102] for example, proposed using the statistical method of least squares to estimate the number of required staff units.

Annual average daily attendance is plotted against the associated number of employed staff on a graph. A line which represents a linear relationship is estimated. The line minimizes the sum of the squared distances from each of the observed points to the line. If enrollment can be estimated, the number of required staff units can be predicted. The sensitivity of the projected estimates can be tested by varying the rate of cost/unit, enrollment, and staff requirements.

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[100] Dei Rossi, PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING, p. 108.

[101] *Ibid.*, pp. 108-109.

[102] *Ibid.*, pp. 100-112. A discussion of statistical techniques for estimating relationships between variables is contained in M. Ezekiel and K. Fox, METHODS OF CORRELATION AND REGRESSION ANALYSIS, (New York: Wiley, 1963), p. 108.

Estimating Social Costs

Social costs are difficult to estimate since many intangible values are involved. It is fallacious to assume that social costs are approximately equal to program costs, according to Merewitz and Sosnick,[103] because:

1. Future expenditures are hard to predict for three reasons:
    a. The stream of outputs to be produced will be uncertain;
    b. The outlays needed to produce any given stream of outputs will be uncertain; and
    c. The outlays needed to produce any given stream of outputs will depend on what decisions are made about other projects.
2. Outlays that will be made in a year do not in fact equal the monetary value of the project's social costs in that year. This inequality has two causes:
    a. Future outlays reflect only explicit costs; they ignore implicit costs such as externalities or opportunity costs;
    b. Outlays reflect uncorrected input prices. When a program uses inputs, other output that the inputs could produce is sacrificed.

Discounting or Present Value Analysis

Discounting is a method of calculating total program costs over several years, or over the program's life time regardless of its time profile (beginning and ending dates). This allows for a stream of data permitting cost comparison of alternatives with different time profiles. Through discounting, the cost streams of alternative systems are compared as if all costs had been incurred at one point in time. This is important since the value of the dollar changes over time. After discounting, the total cost stream of various alternatives which occur at different points in time may be compared.

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[103] Merewitz and Sosnick, BUDGET'S NEW CLOTHES, pp. 212-217.

Before discounting can occur, estimates are needed for the following items of data:

1. An assumed rate of interest;
2. The length of the program over which the systems are to be compared;
3. The initial investment cost and the expected value (estimated remaining useful life of a system) at the end of the program; and
4. The annual operating costs.[104]

Using a standard compound interest formula, if X_t, the future value at time t of X_o, $= X_o\ (1 + i)^t$, where i = rate of interest, then

$$X_o = \frac{X_t}{(1+i)^t}$$

The present value of a stream of costs, $V_o(X)$, then is[105]

$$V_o = \frac{X_1}{1+i} + \frac{X_2}{(1+i)^2} + \ldots \frac{X_n}{(1+i)^n}$$

or

$$V_o(X) = {}^{t=n}_{t=1}\ \Sigma\ \frac{X_t}{(1+i)^t} \qquad \sum_{t\,=\,1}^{t\,=\,\mu} \frac{X_t}{(1+i)^t}$$

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[104] J. G. Abert, SOME PROBLEMS IN COST ANALYSIS, AD 469 240, (Springfield, VA: Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, 1965), p. 26.

[105] Thomas, THE PRODUCTIVE SCHOOL, pp. 22-3.

A problem arises in a cost analysis when the cost of an educational program which has been operating is compared to the costs of a new program. Abert[106] discussed this problem as it relates to defense systems, but analogies to education are appropriate.

The implementation of new programs generally entails high initial costs, whereas in ongoing programs the initial costs are already sunk. Thus, if one seeks to compare the future costs of an ongoing program with those of a new program, rather than comparing the lifetime costs of both programs, the mathetical computation is different than that shown in the above formulation. Two formulas are required--one for calculating the resource impact of investment expenditures and one for calculating the resource impact of operating costs.

Abert suggested that discounting rates should "reflect the time preferences, including risk and uncertainty, for resources today as opposed to resources in the future, of the most likely potential alternative users of resources...".[107] If the utilization of resources is postponed for future consumption, then those unspent dollars can be "stored" to increase the future stock of available resoureces. Higher discount rates generally favor ongoing systems, because large investment costs are concentrated at the beginning of a program's life-cycle. Although maintenance and operating costs are higher for ongoing systems, they are spread out over the program's time horizon. The lower cost for a system with postponed expenditures serves to free up resources for alternative uses or for stockpiling for future investment. Therefore, Abert concluded, "from the standpoint of the resource impact on the economy, the total cost of a system with postponed expenditures is less than that of a system with large initial expenditures."[108]

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[106] Abert, SOME PROBLEMS ON COST ANALYSIS, p. 24.

[107] *Ibid*., p. 25.

A question arises as to the appropriate life span to be used in calculating future costs, that is, what time horizon is appropriate? It has been suggested that a "reasonable time horizon is the economic or service life of the project's longest-lived fixed asset."[109]

Resource Impact of Investment Expenditures[110]

By investing I dollars in a system over a time period, there is a loss of potential growth of Ir for each year, where r = annual rate of return. Over several years the cost of resource growth is $I_1r + I_2r$ t ... I_tr, where t = an investment year.

Using the concept of present value analysis,

$I_ir = \frac{I_ir}{(1 + r)^i}$ and the sum over time t equals $I_r \sum_{t=1}^{i} \frac{1}{(1 + r)^i}$.

In addition to the loss of resource growth, there is an additional cost due to the obsolescence of the system at a rate k each year. Obsolescence is the market's evaluation of the remaining useful life of the system at time t. If kI dollars of resources are lost for t years then the present value of the loss equals $\frac{tkI}{(1+r)^t}$. Thus the total investment costs ($\bar{I}_o$) equals $\left[Ir \sum_{i=1}^{t} \frac{1}{(1+r)^i} \right] + \left[\frac{tkI}{(1+r)^t} \right]$

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[108] The calculation of investment and operating costs are presented by Abert in the above citation on pages 26-8.

[109] Merewitz and Sosnick, BUDGET'S NEW CLOTHES, p. 110.

[110] Ibid., pp. 29-30.

Resource Impact of Operating Costs

Similarly, the present value of the sacrifice in resource growth due to annual operating costs over time t equals $Ar \sum_{i=1}^{t} \frac{1}{(1+r)^i}$. The present value of the cost of resources consumed is $A \sum_{i=1}^{t} \frac{1}{(1+r)^i}$. Thus total operating costs ($\bar{A}_o$) over time t equals

$$Ar \sum_{i=1}^{t} \frac{1}{(1+r)} + A \sum_{i=1}^{t} \frac{1}{(1+r)^i} \text{ or } \bar{A}_o = A \sum_{i=1}^{t} \frac{1}{(1+r)^{i-1}} .$$

A basic assumption here is that resources are withdrawn from the economy at the beginning of each time period and consumed by the end of each time period.

Total Resource Impact of Investment and Annual Operating Costs Over Time t

For purposes of computation, the sum of $\bar{I}_o$ and $\bar{A}_o$ can be reduced to $1 - \frac{(1-tk)I}{(1+r)^t} + A \left[\frac{1 - \frac{1}{(1+r)^t}}{1 - \frac{1}{(1+r)}} \right]$

Omissions of Discounting

Several points have been made by Abert which reveal those aspects of cost analysis to which discounting does not respond:

1. Discounting does not take cost inflation into account. In fact, discounting has the opposite effect;
2. Discounting does not offer any information on the total expected life of a system;
3. Discounting reveals nothing about how rapidly a system deteriorates with regard to use depreciation;

4. Discounting is not a method for evaluating the worth (in a subjective sense) of being able to change one's mind as a result of having procured a short-lived system instead of a long-lived one; and
5. Discounting does not show how many years a study should encompass, i.e., how long into the future a study should look.[111]

Variability of Cost Estimates

Some costs provide an approximation of actual program resource consumption. Boardman[112] suggested that cost data should be accompanied by an interval estimate of the accuracy of that data. Each cost category would include a tolerance or error factor of plus or minus so many dollars, for example, "$125.00 + $5.00." Therefore, instead of point cost estimates for cost categories, an interval is provided. The cost analyst uses the estimate as an indicator of the relative accuracy of each alternative's cost data.

Determine the Effectiveness of Each Alternative

As was the case in the previous section on cost determinations, there is a plethora of literature available from which one may draw in an attempt to handle the question, "What portion of educational performance can be attributed to a specific program?" Included in the following review is a discussion of the appropriateness of measurement scales and gain scores, the identification and management of data which affect student performance, and a delineation of relevant basic descriptive and inferential statistics.

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[111] Abert, SOME PROBLEMS IN ANALYSIS, pp. 29-30.

[112] Gerald R. Boardman, Private interview held at the University of Nebraska in November, 1973.

Classification of Variables

All factors involved in determining program effectiveness may be classified into a variable set. It is the nature of these factors, and of their scale of measurement, that determines the statistical procedure which should be utilized. Factors may be classified according to the following typology:

1. Independent variable is sometimes referred to as a treatment variable and is the presumed course in any educational endeavor. An innovative program, a teaching method, or instructional material are examples of independent or treatment variables.
2. Dependent variable represents an outcome or objective. Scores of achievement tests, attitude scale scores, and ratings by teachers, peers, and others are examples of dependent variables. They are presumed to depend on the effect of the independent or treatment variable.
3. Control variable is an item of information about a student that was obtained before the student entered the program. Scholastic ability or IQ scores, previous achievement test scores, background factors, and ratings by former teachers are examples of control variables.
4. Supplemental variable is an item of information much like a control variable. They are obtained, however, after the treatment or program begins. They are also not dependent variables since they were not obtained at the conclusion of the program and do not, consequently, constitute a fair measure of the effectiveness of a program.[113]

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[113] Richard M. Wolf, "Data Analysis and Reporting Considerations in Evaluation," in W. James Popham, ed., EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, Ca.: McCutchan, 1974), pp. 205-6.

Types of Measurement Scales

Nominal, ordinal, interval and, to a lesser extent, ratio scales are used in educational and psychological measurement and evaluation:

> 1. Nominal scale is the lowest level of measurement. This scale or measure assigns numerals, letters, or some other identifying label to each subject or object...No ordering of the various categories of a variable is intended... Each category is discrete and does not necessarily represent a scale position.
>
> 2. Ordinal scale or measure assigns numerals to subjects or objects which are rank ordered with respect to some characteristic ... It does not indicate, however, the amount of difference between the individuals.
>
> 3. Interval scale or measure defines a unit of measurement such that the difference between units is equal ... Thus, an interval scale permits statements not only as to the difference between the two in comparison with the difference between another pair of subjects.
>
> 4. Ratio scale is the highest level of measurement. This measure is an interval scale having an absolute zero point, so that it is meaningful to speak of one scale value being twice as large as another.[114]

Nature of the Data

The selection of an appropriate statistical procedure from which to draw inferences from the results of research findings is dependent upon one's knowledge of the nature of the data utilized. Descriptive statistics and graphic procedures are available for such purposes.

A descriptive statistic summarizes a set of sample data from observations of a variable attribute at one point in time; it represents the data. The mean, standard deviation, and frequency distribution are used with interval scale measurements. The median, interquartile or semiquartile are appropriate for measures on an ordinal scale. Measurement on a nominal scale involves a count of the number of observations in a particular category. Histograms and bivariate scatterplots reveal the nature of data distribution. Bivariate scatterplots disclose the linear or curvilinear relationship between two variables. On the other hand, inferential statistics are based upon assumptions about a distribution and multivariate relationship.

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[114] *Ibid.*, pp. 213-14.

The use of inferential statistics follows the acquisition of knowledge about the nature of the data. Inferential statistics are employed to allow one to make statements about the impact of various educational treatments, e.g., programs, on a criterion measure of educational output.

Wolf[115] has labeled another stage of data analysis "descriptive-comparative." But he cautioned that it is not a satisfactory substitute for a well-designed study where control or comparison groups are employed to test the efficacy of an educational treatment. A descriptive-comparative approach uses the performance of a norm group on a particular criterion measure, such as a standardized achievement test. In both cases, pre- and post-testing provide the means for comparing gain scores.

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[115] *Ibid.*, pp. 221-22.

Design of Effectiveness Evaluation[116]

In designing an evaluation of effectiveness, conditions should exist which allow for some conclusion to be drawn concerning the nature and extent of a cause-effect relationship, if one exists. Causality implies three conditions:

1. It is necessary to demonstrate that the presumed cause of some outcome did in fact precede the observed effect and that the effect was not present before the causative factor was applied.
2. There exists a statistical relationship between the presumed cause and the anticipated effect (covariation).
3. Causality is based upon the demonstration of a one-to-one relationship between the observed outcome and the purported cause of that outcome.[117]

Cause-effect relationship may be predicated to the extent that alternative relationships are either absent or accounted for, and alternative explanations are negated or dismissed from consideration.

The design is important in that it is an arrangement of conditions to insure valid data gathering, thereby making possible a judgment about a program's (treatment's) worth. The design should attempt to eliminate or control other explanations so as to focus solely on the cause (program or treatment) - effect relationships hypothesized. If the results of an evaluation are generalizable to a larger population of groups, settings, schools, etc., then those results are said to be externally valid. Most locally restricted studies are more concerned with internal validity, that is, the ability to arrive at unambiguous results. The following threats to internal validity have been listed:

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[116] Peter W. Airasion, "Designing Summative Evaluation Studies at the Local Level," in W. James Popham, ed., EVALUATION IN EDUCATION, (Berkeley, Ca.: McCutchan, 1974), pp.147-199.

[117] *Ibid.*, pp. 160-1.

1. History -- events external to the program, policy, or practice under investigation which occur between pre- and post-testing.
2. Maturation -- natural biological, psychological, or sociological development of subjects occurring between pre- and post-testing.
3. Instability -- unreliability of measures, which causes fluctuation in scores independent of the program, policy, or practice under investigation.
4. Testing -- the effect of taking a test at one point in time.
5. Instrumentation -- the effect of changes in the measuring instrument between pre- and post-tests so that observed effects are a result of the instrument change and not the program, policy, or practice.
6. Selection -- biases resulting from differences between types of individuals recruited for comparison groups.
7. Mortality -- differential loss of subjects from comparison groups.
8. Statistical regression -- the effect of selecting individuals on the basis of their extremely high or extremely low scores on a measuring instrument. Scores at extreme ends of a distribution are unreliable and retesting tends to result in either extremely high scorers scoring relatively lower and hence "regressing" downward test scores or extremely low scorers scoring relatively higher and hence "regressing" upward in test scores. Unreliability of test scores at extreme ends of the distribution, in and of itself, results in changes in scores upon testing.[118]

If instructional intervention occurs in a treatment group, the impact of which will be compared against a control group and where subjects were assigned to groups by means of random procedures, a true

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[111] *Ibid.*, pp. 162-3.

experimental design is represented. In the typical school setting, however, evaluation designs must contend with unequivalent preestablished comparison agroups, self-selection, erosion of control subjects, and other factors that confound an evaluation study and threaten its internal validity. In the typical situation, the impact of two or more instructional programs will be compared on groups whose members were not randomly assigned. The greater the divergence between the two groups, the greater will be the threat to the internal validity of an evaluation. It is helpful, therefore, to select treatment groups which are as nearly equivalent as possible. The results of a pretesting of groups on the dependent variable measure provides assistance in interpreting posttest results.

Two typical quasi-experimental designs, which appear appropriate to the task at hand, will be described and issues related to internal validity discussed. One design consists of a pretest and posttest administered to two groups at two points in time between which there has occurred a period of instruction. The more similar the comparison groups, the lesser will be the effect of history, maturation, testing, and instrumentation. Thus, internal validity is increased because the threats to validity are expected to affect both groups similarly. The more dissimilar the groups, the greater likelihood that statistical regression phenomena and the stability and reliability of the instrumentation (discussed in an earlier section) will affect the outcome. On posttesting, the scores of students who possessed extremely low or extremely high scores on the pretest, are likely to regress toward the mean. In general, the more homogeneous the groups, the less reliability or stability possessed by a measuring instrument. The stability of a measure is also suspect when differences between groups are great.

The control time series design developed by Campbell and Stanley[119] includes a number of pre- and post-test measurements made at different times which allows for study of the immediate and longer-range impact of an instructional treatment which has desirable general cognitive or affective outcomes. A series of equivalent measures are needed for the retests. The greater the number of outcomes obtained, the more complicated are the comparisons of the treatments. With a number of pretestings, the effects of group selection, the phenomena of statistical regression, and instrumentation are more likely to be revealed and thus may be accounted for prior to treatment.

Equated Test Forms and Tailored Tests

Test forms are equated so that the derived normative scores between forms are directly equivalent after they are converted from raw scores. Different forms of the same test to be administered at the same placement level are constructed to have comparable item content and similar distributions of item statistics. Test forms are equated to adjust for any unintended differences in difficulty of test items or differences in distributions of the examinees. This is termed horizontal equating.[120]

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[119] D. T. Campbell and J. C. Stanley cited in Ibid. Other references which present quasi-experimental designs are cited by Airasian.

[120] W. H. Angoff, "Scales, Norms, and Equivalent Scores," in R. L. Thorndike, ed., EDUCATIONAL MEASUREMENT, SECOND EDITION, (Washington, D.C.: American Council on Education, 1971), p. 562.

One test form may be intentionally designed to be more difficult than another in order to measure achievement at a higher placement level. Such forms contain more difficult items and differ in content specification. Scores from different educational level test forms are vertically equated to a single scale. Linn[121] concluded that since, as stated by Angoff, forms should measure the same characteristic and conversion should be unique, these requirements are not likely to be satisfied for tests to be administered at different educational levels. Thus a pre-post-test comparison of scores may not be appropriate.

As an alternative to the vertically equated test, Linn[122] suggested that tests to measure a broad range of educational levels be developed and that test items could be administered by a computer. In this case test items are selected on the basis of a student's response to previous items, i.e., the items presented to the student are tailored as to their difficulty for each student rather than for a group.

Lord[123] found that norm-referenced test items discriminated the ability of students who were at the difficulty level of the items, but were less adequate as the ability level of students deviated from the difficulty level of the items. Tailored procedures were not quite as good as the standardized test for examinees whose ability matched the difficulty of the test items, these procedures provided better measures of growth for a wider range of examinee ability than did standardized tests. Tailored tests provided excellent measurements at extreme levels.

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[121] Robert L. Linn, "The Use of Standardized Test Scores to Measure Growth," (paper presented at the School of Education Conference, University of Wisconsin-Madison, Madison, Wi., May 2-3, 1974), p. 6.

[122] *Ibid.*, pp. 24-7.

[123] F. M. Lord cited in Levin, "Use of Standardized Test Scales," pp. 25-7.

Normative Gain Scores

If a gain score during a period of educational treatment is to be obtained, pre- and post-testing is required. Both Sax and Linn[124] have asserted the unreliability of gain scores, since they contain the combined errors of measurement of both the pretest and posttest. Kershaw and McKean,[125] on the other hand, were of the opinion that, although errors exist for individual test scores, they could be relied upon for group scores for individual errors tend to balance out. Sax[126] suggested that reliability is improved if each student is pre- and post-tested two or more times using parallel forms and combining standard scores.

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[124] Sax, EVALUATION IN EDUCATION, p. 288. Robert L. Linn, "Use of Standardized Test Scales to Measure Growth," p. 1.

[125] Joseph A. Kershaw and Roland N. McKean, SYSTEMS ANALYSIS AND EDUCATION, RM-2473-FF, (Santa Monica, Ca.: Rand, 1969), p. 11.

[126] Sax, EVALUATION IN EDUCATION, pp. 288-9.

In addition to the error of measurement problem, Sax[127] suggested two additional problems with pre-post comparisons: (1) regression effects and (2) the impact on the internal validity of the experiment. When using tests which are not totally reliable, a portion of a low or high score contains the effects of chance. These chance effects are unlikely to occur in a retest. Thus, scores of low performers will increase and scores of high performers will decrease, i.e., there will be a regression to the mean. In order to avoid this, tests of high reliability and small errors of measurement at the extremes of a distribution should be used. Again, the use of two parallel forms of the same test for both pre- and post-tests should improve reliability--assuming that practice effects are unlikely to occur.

The strength of an experiment's internal validity can have a strong bearing on what may be concluded from the test results:

> Internal validity is the extent to which extraneous variables have been eliminated so that a clear and unambiguous interpretation of the relationship between the independent and dependent variable can be made.[128]

One method, but one which takes considerable time, is to conduct a longitudinal study of students' standard or scale scores over several years using one educational program and then over several years using an alternative program. Randomly assigning students to groups which will experience different educational treatments is another. A third possibility is to equate groups statistically through the use of standardized tests and demographic data. This third choice is the technique adopted in this study and will be dealth with more fully later.

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[127] Ibid., p. 289.

[128] Ibid., p. 289.

Test results have been used to describe student progress during the intervention of special programs and, as a dependent variable, to partial out the effects of school and environmental effects on achievement. Several important questions must be answered in order to determine programmatic effects:

1. What score should be used?
2. How school achievement increments, or "growth," be measured?
3. What kinds of comparisons among schools or students are necessary to permit valid inferences about school effects?[129]

Standardized Test Scales

If it is assumed that test items measure what is learned by subjects during the course of an educational treatment, then a raw score, a measure of the actual number of correct responses, should reflect the total amount of learning which has taken place. These scores often are converted to a normative score to indicate the relative position of the score within a distribution of all scores.

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[129] James A. Coleman and Nancy L. Karweit, MEASURES OF SCHOOL PERFORMANCE, R-488-RC, (Santa Monica, Ca.: Rand, 1970), p. 2.

Grade Equivalent Score

A grade equivalent score for a student or group indicates the relative grade position of the student or group relative to the median of the norm group at that grade level. Several individuals have considered the misinterpretations which are possible when grade equivalent scores are used to measure growth. Using the grade equivalent score, the magnitude of a year of growth depends on the total distribution of scores at that grade level. A year of growth has a greater significance at a lower grade level, since the variance of a grade equivalent score increases from the lower to the upper grades. Although a group of students may have maintained the same percentile rank over time, the grade equivalent of that group may fall farther behind relative to the grade level in which the test was given.

> A student's grade equivalent score is thus a measure, not of his performance relative to the average of others his age, but of the age level of those whose average performance equals his own ... It is a relative score masquerading as an absolute score.[130]

Prescott found that "1.0 years of growth is typical only for those pupils near the middle of the distribution," whereas the maintenance of other percentile scores over time yield average growth rates above or below 1.0."[131]

Grade equivalents are estimated by noting where a score falls on a regression line, which is a result of the regression of scores on grade. Had the line been determined by the regression of grade on score, the scores would have yielded different grade equivalents.[132]

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[130] _Ibid._, p. 12.

[131] G. A. Prescott cited in Linn, "Use of Standardized Test Scales," pp. 10-11.

Percentile Score

"The percentile corresponding to a score in a distribution is the percent of the total group having scores less than or equal to the particular score in question."[133] Percentile scores also suffer a limitation. Coleman and Karewit[134] demonstrated the misleading nature of a percentile score. In the bell-shaped normal distribution, scores are clustered near the 50th percentile, whereas at the extremes of the curve, the scores are spread out and consequently so are percentile units. Thus the difference in two scores near the median represents a larger percentile change than does the difference in scores near the extremities. "According to most points of view, its units are unequal since they are intended to provide equal proportions of a group, not equal intervals on a scale of ability."[135] A comparison of percentile scores does not reflect the amount of change, but the direction of change in relative standing, according to Coleman and Karweit.

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[132] Averch, et al., HOW EFFECTIVE IS SCHOOLING?, p.21.

[133] William L. Hays, BASIC STATISTICS, (Belmont, Ca.: Brooks/Cole, 1967), p. 24.

[134] Cole and Karweit, MEASURES OF SCHOOL PERFORMANCE, p. 17.

[135] Linn, "Use of Standardized Test Scales," pp. 13-15.

Standard Score Based on a Separate Standardization

The standardized score (z score) shows the relative position of a raw score within a distribution of scores and allows for a comparison of a student's or group's standing on one measurement with that same student's or group's standing on another measurement. The relative position is in terms of the departure from the mean measured in standard deviation units. A "standard" mean and "standard" standard deviation are set a 0 and 1, respectively.[136] Coleman and Karweit[137] suggested a way of comparing the amount of change over a specified period of time between two or more groups using different grade level forms of the same test. Each grade level group's percentile score would be converted into a standard score. The conversion changes the metric and zero point of the scale score. The mean for the average at each grade level becomes the same, but for every grade there is a separate standard score. When the mean and standard deviation is the same across grade levels, the amount of change between grade levels in the average score of each group is obtainable.

Standard Score Based on a Single Standardization[138]

Whereas the preceding section compared the amount of group change relative to a norm at each grade level, this section considers the use of a single norm which allows for the calculation of absolute changes over a given period of time. A single standardization is calculated using the pretest distribution of raw scores. The percentile of each raw score is associated with a standard score on the pretest. The percentile of each raw score on the post-test is associated with a standard score using the pre-test standard score scale. The gain in standard score represents the amount of extra gain or "catching up" of a student or group of students. This is viewed as an appropriate method for assessing the relative effect of alternative programs on students or groups at different achievement levels. This method is preferred over the use of the grade-equivalent gain scores because grade equivalent forms can give a misleading picture of the "catching up" attained, as mentioned in an earlier section. For example, a student or group may show a greater gain in standard score when compared to other students or groups but may, in fact, "fall behind" in grade equivalent gain.

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[136] William L. Hays, BASIC STATISTICS, (Belmont, Ca.: Brooks/Cole, 1967), pp. 41-43.

[137] *Ibid.*, p. 13.

[138] *Ibid.*, pp. 15-17.

Grade Score

The Scholastic Testing Service has developed the "grade score" to provide a measure of growth.

> The grade score is obtained by converting percentiles for the norm group to normalized standard scores 'with the mean set equal to the actual grade placement, and with a standard deviation set equal to 1.0.'[139]

The standard deviation of the grade score remains the same at all levels of actual grade placement. As noted previously, this is not the case with grade equivalents. If one achieves the same percentile rank on a pre- and post-testing, the grade score advances 1.0 units. An increase greater than 1.0 suggests more than normal growth.

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[139] *Ibid.*, pp. 21-24.

Linn[140] pointed out limitations of using the grade score to measure change. A student whose raw score is the same on a pre- and post-test would probably show a gain in grade score units.

> This undesirable feature is a consequence of applying different transformations to the raw scores from the same test form at different grade levels ... Further the gains in grade scores associated with constant raw scores vary according to raw score.[141]

Both the grade equivalent score and the grade score associated with a "chance level" raw score (what would be expected by randomly responding to all items with different test forms and grade level placements) may cause some misrepresentations of growth.[142] When converting a chance level raw score using the same test form, the grade equivalent score is the same at each grade level and the grade scores are different. If the chance level raw score is different for two separate test forms, e.g., elementary and advanced, the grade equivalent score at chance will be different for each test form. This may lead to an erroneous conclusion with regard to comparable chance performance between test forms. When chance level raw scores differ, grade scores show a larger increase relative to grade level placement than with a lower chance level raw score.

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[140] Linn, "Use of Standardized Test Scales", pp. 13-15.

[141] _Ibid_., p. 13, 15.

[142] _Ibid_., pp. 15-17.

Scores Adjusted for Correct Response Probability

Many of the difficulties in the use of standardized tests stem from the need for measuring growth over several years. Current test scales, as previously mentioned, are fraught with limitations. It has been suggested that respondents' scores should be compared based upon an adjustment for test difficulty by calculating the probability of a correct response.[143] That probability has four components:

a. individual's location on the latent trait which is related to item characteristics;

e. item easiness or difficulty;

d. item discriminating power; and

q. probability of a correct response to an item being greater than zero even for the lowest levels on a latent trait, i.e., obtaining the correct answer by random guessing.

One such model, developed by Rasch, calculates that the probability of person i getting item j correct (P..) is equal to $\frac{a_i e_j}{1+a_i e_j}$. Thus statistically equivalent measures are obtainable. The Rasch model does not consider parameters d and g.

> Although it has been argued that the Rasch model is robust with respect to violations in the assumptions of equal discriminating power and zero probability of correct answers due to random guessing, the adequacy of the results will obviously depend in part, on the severity of the violations of these assumptions.[144]

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[143] Ibid., pp.21-24.

[144] Ibid., p. 23.

If test items in different grade level forms of the same test measure different latent traits, the use of the Rasch model should make this situation more explicit but does not adjust for it.

Time[145]

The time period specified for measuring the amount of learning which has occurred under different educational treatments can affect the outcome of curricular evaluation. As shown in Figure 5.16, when performance is plotted against time, learning curves of two groups (A and B) receiving different educational treatments may intersect.

Standardized Tests in Evaluation *293*

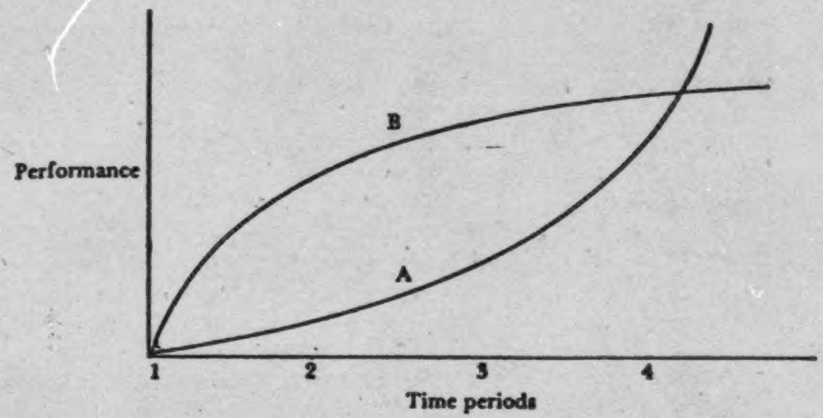

Figure 5.16--Two Hypothetical Learning Curves Measured in Relationship to Different Time Periods or Specified Performance Levels

Source: Gilbert Sax, "The Use of Standardized Tests in Evaluation," in W. James Popham, ed., EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, Ca.: McCutchan, 1974), p. 293.

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[145] Sax, EVALUATION IN EDUCATION, pp. 292-293.

Rather than (or in addition to) examining the amount of learning which occurs during a specified time period, it may be useful to evaluate the amount of time required for a group of students to successfully attain a given criterion level of effectiveness. Alternative programs could be compared using time as a dependent variable. If a level of performance is specified at a time when the A and B learning curves intersect, however, no difference in time will be noted.

Distribution of Gain Scores

An instructional treatment may not impact equally on all students. Consequently, it would be helpful to show, in addition to an average gain score for the entire group, the gains obtained by students whose scores fall some distance from the indicator of central tendency. The distribution of scores is concealed by that indicator. In fact, the nature of any changes in a distribution of scores from pre to post-testing is concealed.

The use of the mean standard score and standard deviation has been suggested.[146] Since a standard deviation is an indicator of variability from an average score, the change in variability over time in a distribution of test scores indicates whether a group of students is becoming more or less homogeneous. In conjunction with the change in standard score, there is an indication of whether high or low achievers are showing extra or deficient gains.

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[146] Coleman and Karweit, MEASURES OF SCHOOL PERFORMANCE, p. 33.

An alternative to the above method[147] is the use of central tendency for groups of students that fall into a particular level within the total distribution of scores, e.g., quartile or quintile.

Gain Scores for Domain-Referenced Tests

Millman[148] has suggested two approaches for estimating domain scores from domain-referenced tests (DRT's): the binomial model and the Bayesian model as described by Novick, Lewis, and Jackson[149] and by Lewis, Wang, and Novick.[150] In DRT's items are randomly selected from a pool of items representing each domain for which students receive instruction. Therefore, domain scores must be estimated from test scores by calculating the "level of functioning or the percentage of items likely to be answered correctly if the entire set of items in the domain were administered."[151]

There are several features common to both procedures:

1. Generalizations about an individual's test score are applied only to a large population of items from which the test items were randomly drawn.

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[147] *Ibid*., p. 34.

[148] Millman EVALUATION IN EDUCATION, pp. 341-32.

[149] Melvin R. Novick, Charles Lewis, and Paul H. Jackson, "The Estimation of Proportions in M Groups," PSYCHOMETRIKA 38, 1973), 19-46.

[150] Charles Lewis, Ming-Mei Wang, and Melvin R. Novick, MARGINAL DISTRIBUTIONS FOR THE ESTIMATION OF PROPORTIONS IN M GROUPS, Technical Bulletin No. 13, (Iowa City, IA: American College Testing Program, 1973).

[151] Millman, EVALUATION IN EDUCATION, p. 341.

2. No consideration is given to the effect of item difficulty or the homogeneity of item content.

3. An individual's response to a test item is scored as correct or incorrect.

4. An assumption is made that there is no effect on the response to subsequent test items from answering previous ones, that is, responses are independent of each other. No learning or interference transpires.[152]

Millman noted that violations of the above assumption are quite possible.

Specification of Multiple Output

Two approaches generally have been used to represent output from several measures.[153] In one approach an index is calculated to represent an aggregate measure of output--which in essence produces a weighted average effect of a number of outputs. In the other approach, a separate production function is specified for each output, thus providing information about each input-output relationship.

Time Dimension in Educational Production

Although it may appear that the time dimension is neglected in cross-sectional studies, it has been suggested that such studies may have an implicit time dimension.[154] Inputs affect output over time, and cross-sectional analysis often calculates the change in input and output over time. Time is made more explicit when a change in student output over an instructional time period is postulated. In the case of certain background variables, this input is acquired at the beginning of the time period, or if such background variables are stable they may be estimated during or at end of the time period.

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[152] *Ibid.*, p. 341.

[153] New York State Education Department, VARIABLES RELATED TO STUDENT PERFORMANCE AND RESOURCE ALLOCATION DECISIONS AT THE SCHOOL DISTRICT LEVEL, (Albany, NY: State Education Department, 1972), p. 44.

[154] *Ibid.*, pp. 45-47.

Unit of Analysis, Variable Averaging, and Data Aggregation

A specification of input-output relationships will depend in part on the level--state, district, school, classroom(s)--at which data are aggregated. At the district or school level, school and nonschool inputs are averaged and associated with average district or school performance. Observations of variable attributes are only possible at certain levels of aggregation. Data are essentially disaggregated at the student level, but the effect of variables for which only aggregated data are available must be considered. These variables can be accounted for by including variable averages in a production function of individual student performance.[155]

Cooley[156] presented strong arguments for using the classroom as the unit of analysis when evaluating instructional programs. In his view, programs or instructional models are implemented in varying degrees by teachers in the classroom.

> Since a convincing evaluation study must include a variety of classroom settings, and since these classrooms will vary in the degree to which different aspects of the

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[155] *Ibid*., pp. 47-49.

[156] Cooley, "Methods of Evaluating School Innovations," pp. 8-9.

> instructional model are implemented, establishing dimensions for measuring degree of implementation and using the classroom as the unit of analysis in a correlational model seem to be promising approaches to explore.[157]

It is at the classroom level that instructional process variables are observable. By using the classroom as the unit of analysis, one may compare the effects on output achieved by different input distributions.

Grouping or Clustering Variables

Factor analysis is a statistical technique which may be employed to organize large number of variables into manageable groups or clusters. Kerlinger explained that:

> Factor analysis is a method for determining the number and nature of the underlying variables among larger numbers of measures. More succinctly, it is a method for determining k underlying variables (factors) from n sets of measures, k being less than n. It may also be called a method for extracting common factor variances from sets of measures.[158]

Factor analysis clusters variables together (into factors) thereby indicating which ones measure the same thing and to what extent. If a test or variable measures only one factor, it is factorially pure, or it may measure a factor to some extent (factor loading) in the form of a correlation coefficient. It may be factorially complex, i.e., measure more than one factor. An intercorrelation matrix is first determined on each n variable using quantitative data on each variable from each subject. Factor analysis then reduces these variables to uncorrelated factors expressed as a linear combination of the original variables. In principal component analysis, the common factor which accounts for the largest part of the variance in the correlation matrix is extracted first followed by that common uncorrelated factor which accounts for most of the remaining variances, and so forth.[159] A matric of factor loadings provides a correlation between each factor and each variable.

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[157] Ibid., p. 9.

[158] Fred N. Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, SECOND EDITION, (New York: Holt, Rinehart and Winston, 1974), p. 659.

A cluster or composite variable (factor) "presumably would more accurately specify," for example, "socioeconomic status than any one of its components."[160] By utilizing factor analysis, grouping may reduce multicollinearity, thereby resulting in better estimates of the independent impact of clustered inputs on output.

There are disadvantages associated with the use of factor analysis.[161] For example, it is difficult to interpret a factor when highly intercorrelated variables, which represent two or more conceptually different phenomena, load on the same factor. By grouping variables, subsequently, only one regression coefficient is obtained for each cluster. This eliminates the possibility of estimating changes in output from changes in individual input. Consequently, there will exist an incomplete specification of the production function because the direct influence of individual inputs is lost. The relative effects of different categories of inputs, however, is obtained.

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[159] Dennis W. Spuck, Donald N. McIsaac, and John A. Berg, PROGRAM BIG FACT (RAND Q-MODE FACTOR ANALYSIS PROGRAM), (Madison, Wi.: Wisconsin Information Systems for Education, University of Wisconsin-Madison, 1972).

[160] New York State Education Department, VARIABLES RELATED TO STUDENT PERFORMANCE, p. 50.

[161] *Ibid.*, pp. 50-51.

> If the variables are such that they can be grouped in theoretically or policy meaningful terms, then not grouping would seem to result in a decline in credibility of the regression statistics and a sacrifice of knowledge of the relative impact of different general types of inputs.[162]

A Matrix of Inferential Statistical Procedures

Wolf developed a matrix table (see Figure 5.17) to facilitate the selection of an appropriate statistical procedure. The procedure is based upon:

1. The number of independent and dependent variables under study;
2. The type of scale on which each variable is measured; and
3. The nature of the distribution of the variables.[163]

In this matrix, within each quadrant a higher order measurement scale variable may be analyzed using the statistical procedures appropriate for lower order measurement scale variables. In other words, a higher order statistical procedure may be used with higher order measurement variables. However, lower order measurement scale variables can not be analyzed using procedures relevant to higher order measurement scale variables. Statistical procedures applicable

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[163] Wolf, EVALUATION IN EDUCATION, pp. 222-23.

			DEPENDENT VARIABLES					
			One			Two or more		
			Nominal	Ordinal	Interval	Nominal	Ordinal	Interval
INDEPENDENT VARIABLES	One	Nominal	Chi-Square Test for Independence Contingency Coefficient Cochran Q Test Fisher Extract Probability Test for 2 x 2 Tables	Sign Test Median Test Mann-Whitney U Test Kruskal-Wallis One-Way Analysis of Variance	Analysis of variance (analysis of covariance)			Multiple discriminant analysis
		Ordinal		Spearman's Rank Correlation Kendall's Rank Correlation	Analysis of variance (analysis of covariance)			
		Interval	Analysis of variance (analysis of covariance)		Regression analysis (multiple coefficient) correlation	Analysis of variance (analysis of covariance)		Multiple regression analysis
	Two or more	Nominal		Friedman Two-Way Analysis of Variance	Analysis of variance (analysis of covariance), factorial design			Analysis of variance (analysis of covariance)
		Ordinal						
		Interval	Multiple discriminant analysis	Multiple regression analysis		Multiple discriminant analysis		Canonical correlation

Figure 5.17--Statistical Techniques Classified According to Type, Number, and Measurement Scale of Variables

Source: Richard M. Wolf, "Data Analysis and Reporting in Evaluation." in W. James Popham, EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, Ca.: McCutchan, 1974), p. 224.

for lower order scales that are used with higher order scales are less powerful devices. In cases, however, where data fail to meet the assumptions of a particular technique, the use of a less precise technique will be required.

There may be cases in which more than one level of measurement scale is represented by the independent or dependent variables in a problem. Separate statistical analyses may be required. One could presume that the variables in a measurement scale represented by the fewest variables could be labelled in the measurement scale represented by the other variables. The distinction as to which measurement scale represents those variables may be a narrow one. In situations where the appropriate cell is blank, one could conduct a separate analysis of each variable. Wolf suggested that "there is greater risk in using a statistical procedure that is inappropriate for one's data than in analyzing data one variable at a time if there are only a few variables to be considered."[164] When one is not clear as to the scale on which a variable is measured, the lower level scale is the safer one to employ, although it is the less powerful.[165]

Selection of Input Variables for Multivariate Statistical Analyses

The first step in selecting input variables for multiariate statistical analyses is to identify a potential list of variables and their proxies which may correlate with the dependent (criterion) variable(s). (The review of the literature reported in Chapter III provided for such a listing.)

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[164] *Ibid.*, p. 226.

[165] *Ibid.*, p. 213.

Both Sax and Cage[166] advised selecting those input variables which have the highest correlation with the output measure(s) and the lowest correlation with each other after computing all possible input-output associations. "Generally, no more than three or four covariates are used since additional ones contribute inconsequential increments in equating groups."[167]

It is not uncommon to find researchers making value judgments as to which variables should be included in a production function rather than first subjecting a list of variables to associational analysis to determine if the relationship is significant. It would not be surprising, however, to find that variables which are correlated significantly with an output variable may not maintain significance where subjected to multiple regression analysis. The interrelationships of input variables may obscure the impact of each input variable on the output measure. On the other hand, a variable may be an important affector of output, but only indirectly as it interrelates with other inputs.[168]

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[166] Sax, EVALUATION IN EDUCATION, p. 291; Bob N. Cage, "Measuring Productivity in Education" in SCHOOL FINANCE IN TRANSITION, (Gainesville, Fla.: National Educational Finance Project, 1973), p. 98.

[167] Sax, EVALUATION IN EDUCATION, p. 291.

Several techniques have been identified in Figure 5.12 which will assist in the selection of input variables for multivariate statistical analyses. They involve regression and correlation methods, one-way analysis of variance and covariance, chi-square tests and order statistics.

Regression and Correlation Analysis

Linear correlation and regression are techniques appropriate when a linear relationship between two variables is established. The observations of variables take on numerical values. The linear prediction function rule between two variables X and Y is:

$Y = bX+a$; where b and a are constants
($a = o$ when predicting standard scores)

In regression analysis X is the independent variable and the value of y is dependent upon the value of X. In correlation, no distinction is drawn between independence or dependence. The question is can one be predicted from the other or vice-versa? The value of each observation is converted to a standard z score.

Correlation and regression theory are based upon the least squares criterion.

> We want to choose constants for one linear prediction equation in such a way that the average squared error in prediction will be as small as possible.[169]

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[168] New York State Education Department, VARIABLES RELATED TO STUDENT PERFORMANCES AND RESOURCE ALLOCATION DECISIONS AT THE SCHOOL DISTRICT LEVEL, (Albany, N.Y.: State Education Department, 1972), pp.42-3.

[169] *Ibid.*, p. 496.

A sample variance of estimate for standard scores reflects the linear rule's "poorness" in predicting standard scores of Y from X or X from Y. The value of its square root, the standard error of estimate, is inversely related to the absolute value of the correlation coefficient (xy). Rxy=b for the prediction of standard scores. The value of xy may range from -1 to +1. When xy = 0, no predictive statistical relationship exists. When xy = +1 or -1 prediction is perfect in that the variance of error is zero. The square of a correlation coefficient represents the variance in Y accounted for by specifying X.

It is not necessary to make any assumptions about the form of the distribution of sample values unless one wishes to infer beyond the sample to a population. Bivariate normal distributions have been most often employed. Correlation (pxy) and regression indices for populations are analogues to sample indices. Correlation and regression are discussed further in the following section on multivariate statistical analyses.

One-way Analysis of Variance (ANOVA) and Analysis of Covariance

One-way analysis of variance applies where there is one qualitative (nominal scale) independent experimental variable or factor and one quantitatively (interval scale) measured dependent variable. "One-way" refers to the fact that sample groups are compared only as they differ systematically in one way. The "fixed effects" statistical model applies in this case where the interest is only in a small set of treatments or a combination of those treatments included in the experiment.[170] At interest is whether or not a functional relationship exists between the treatment and the dependent variable. All other possible factors are controlled. The effect of random error cancels out uncontrolled factors. The deviation of the mean of the observations of each treatment population is compared to a grand mean as an indication of a statistical relationship. Consequently, the fixed effects model contains four components of which Yij is an observation after treatment and a function of (1) a grand mean across all treatment populations, (2) the effect associated with a particular treatment, and (3) the random error associated with the treatment-subject combination. The differences (variability) in observations are due to different treatments of chance variation. The variations between and within groups reflect total variation and are taken into account in calculating the sum of squared deviations (SS):

SS total = SS within + SS between

Only variations due to chance operate within groups, but both chance and treatment effect may cause variations between groups. The sums of squares are used to formulate a mean square between groups and a mean square within groups. These mean squares (variances) are used to test the hypothesis of no effects due to treatment.

This statistical procedure operates under the assumption that errors are distributed normally between and within groups and that errors are independent with respect to any pair of observations. The F ratio of mean squares is used to test for significant differences between treatments.

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[170] William L. Hays, STATISTICS, (New York: Holt, Rinehart and Winston, 1963), pp. 360-62.

Analysis of covariance[171] uses the sums of cross products, covariances, and sums of squares to test for the significance of differences between treatment means. It is concerned with the significance of differences between treatment means. It is similar to analysis of variance, but equates groups statistically rather than matching subjects or randomly assigning them to groups. In essence, effects in data due to unequal groups are partialed out. Covariance is defined as the average of the cross products of the deviation from mean scores of two variables, X and Y. If the deviations of associated X and Y scores are multiplied, the sum of these cross products is analogous to the sums of squares in ANOVA. The XY relationship is partialled out of the Y sums of squares yielding an adjusted total, between-groups, and within-groups sums of squares. Mean squares and F ratios are used to test for significance differences.

Chi-Square Tests

Several Chi-square methods may be utilized to examine the association between an independent and a dependent variable measured on a nominal scale, i.e., both variables have qualitative attributes. Chi-square methods allow one to study the association of two variables from categorical data without the availability of such descriptive statistics as means or variances. The central problem is that of making inferences about a population distribution from a sample distribution. If any discrepancy does exist between the sample and theoretical (population) distribution, a test for "goodness of fit" is available which permits such inferences. Inferences are made by approximating an exact multinominal probability of a population and comparing it to the sample distribution. Without a χ^2 approximation, exact probability computation is either impossible or tedious.

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[171] Fred N. Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, (New York: Holt, Rinehart and Winston, 1964), pp. 347-51.

Pearson χ^2 Tests for Independence.-- Pearson χ^2 tests seek to determine whether variables are independent, that is, whether a statistical association is lacking. The cells of a contingency table display the frequency of joint events between mutually exclusive and exhaustive classifications of observations on a variable. Not only must each and every observation be independent of the others and qualify for only one cell, but sample size must be large (size requirements vary as to degrees of freedom).

If a result is statistically significant, it is inferred that the samples were not drawn from the same population. This differs from parametric statistics, where conclusions may be drawn not only about whether populations differ, but how and by how much they differ. The use of scores from an interval scale allows for stronger conclusions in parametric statistics.

Fisher's Exact Probability Test for a 2 x 2 Contingency Table.-- When the sample size is too small to permit the use of χ^2 tests, probabilities may be computed precisely by applying Fisher's exact test. This provides stronger evidence of association.

> If one finds the probability of the arrangement actually obtained, as well as every other arrangement giving as much or more evidence for association, then one can test the hypothesis that the obtained result is purely a product of chance by this probability as the significance level.[172]

The underlying reasoning behind the chi-square and Fisher's exact test differ. Here the sample probability is compared to the distribution over possible randomization of that sample.

The Phi- and Contingency Coefficients -- The Phi-Coefficient (φ^2) is the correlation between two variables when the nominal scales for both have "scores" of 0 and 1. An ordering is suggested here and thus it resembles a correlation between ordinal scale measured variables. A positive correlation indicates an association between the similar categories (0 to 0, 1 to 1) of each variable and a negative sign represents an association between opposite categories (0 to 1, 1 to 1). This is often called the fourfold point correlation method. The Phi-coefficient is applicable to larger contingency tables. The strength of association may be described. The coefficient of contingency (C) may be substituted for φ^2, but is not as useful a measure.

Order Statistics

Classic parametric methods such as methods, the t and F tests require the assumptions that population distributions are normal bivariate and that variances are homogeneous. Regression and correlation are parametric methods. Chi-square tests are nonparametric, since they do not require assumptions of normality. They do require, however, a discrete sampling distribution estimated by probability. Order statistics, on the other hand, can be used in cases where only a set of numerical scores which are ordinal in nature are available, probability. Order statistics, on the other hand, can be used in cases where only a set of numerical scores which are ordinal in nature are available, probability theory is employed, and the assumptions required for use of parametric methods are not met.

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[172] *Ibid*., p. 599.

Cochran Q Test.-- The Cochran Q test is used when the repeated observations of a dependent variable on several subjects are labelled as "success" or "presence" and "failure" or "absence," etc., and assigned a value of 1 or 0. In a sense, the labelling of 1 or 0 as success or failure implies an ordinal scale measurement. Thus, it is a method that has been placed midway between contingency table and order statistics. If the Q statistic is insignificant the null hypothesis is not rejected.

Sign Test.-- The sign test is used when n pairs of subjects are matched and each member receives one of two experimental or natural treatments. The sign of the difference between the post-test scores of each (+, -, or 0) is the basic information used to calculate presence or absence of association. This test is based on a binomial distribution. The theoretical binomial probability is .5 for either sign. Zero differences are dropped. A null hypothesis is a probability equal to .5. The null hypothesis must be rejected for an association between performance and treatment to be demonstrated.

Mann-Whitney U Test.-- The Mann-Whitney U test may also be utilized when observations of a dependent variable are measured on an ordinal scale and the independent variable is measured on a nominal scale. The ranking of observations serves to test hypotheses concerning the identity of two population distributions, that is, the null hypothesis asserts the distributions to be identical. Hays suggested that the test is sufficiently powerful to suffice as an alternative to the t test which examines the relationship of sample means. Comparisons are made between the results of the sample and all of its possible randomizations. Continuous distribution of the underlying variable is assumed. Basically, the scores from two samples are combined and all scores are ranked. The sum of the ranks for scores from observations in each sample are entered into the calculation of the U statistic. Variations in U values should only be a function of the random assignment of individuals to the two groups when the null hypothesis of identical populations is true.

Kruskall-Wallis One-way Analysis of Variance.--The Kruskall-Wallis One-way Analysis of Variance is a generalization of the Mann-Whitney U test where J independent groups are being compared. A numerical score for an observation is given a rank among all scores across all groups. The ranks within each independent group are summed and the totals are entered into a formula. When the statistic is calculated, it is referred to the Chi-square distribution to test the null hypothesis of identical population distribution across all J groups.

Median Tests.-- Order statistics methods also are provided by the median tests which seek to compare two or more independent groups. Again it is assumed that the underlying variable which serves as the basis for comparison of the population is continuous. Another operative assumption is that there is a zero probability that ties between the values of observations will occur. The null hypothesis states that the distributions are identical. In this method a grand median is calculated from all observations across all groups. Then each observation is assigned a plus if it is above the grand median or a minus if it is below this median. If the grand median identically divides the population distributions, then the probability is the same for each and every population (the distribution is binomial) and the null hypothesis is substantiated. In this test the interest is in a comparison of the total frequency of plus observations across all groups with the plus observations of each group. The X^2 statistic is used as an approximation to the exact significance level with large samples unless one painstakingly undertakes to find all possible sample results whose probabilities differ by as much as or more than the sample result.

If groups are matched rather than representing independent random samples, a median test may still be employed. Such a design is known as a randomized block. Each matched group contains a number of subjects equal to the number of treatments. The subjects in each group are randomly assigned to a treatment. The median for the scores in each group is determined. Each score is given a plus or minus depending upon whether it falls above or below the median. The number of pluses for each treatment is counted. The assumption is that the form of the distribution is the same for each and every row and the hypothesis tested is of identical column distribution. A Chi-square statistic is used for determining significance.

Rank Order Correlation Methods.-- Spearman's rank correlation and Kendall's tau coefficient are designed for situations where both the independent and dependent variable are measured in ordinal terms. Whereas the Spearman rank correlation is a correlation coefficient, Kendall's tau coefficient is not a correlation according to Hays. In the matrix developed by Wolf (see Figure 5.12), however, the latter is labelled as Kendall's rank correlation. Both of the methods are indices of "concordance" or "agreement". The size of the correlation or coefficient does indicate a tendency for the two variables to behave in a monotone way, that is, as X values increase, correspondingly Y values increase or decrease. Thus directionality is evidenced. These indices, while not as powerful as regression (rxy) wherein the tendency toward a linear relationship is shown, are more powerful than the phi-coefficient (φ) which indicates some unspecified departure from independence.

The Spearman rank correlation (r_s) for a sample is the correlation between ranks over individuals. The formulation of r_s uses the number of ranked objects and the difference in the rankings.

In the Kendall tau coefficient (τ) an inversion exists when rankings of objects are reversed. The number of inversions take on significance in the formulation rather than the value of the difference of rankings as in r_s. The τ statistic is the difference between proportions -- those pairs having the same relative order minus those having different relative order -- divided by the total number of pairs. The assumption is that variables from which the ranks are drawn are continuously distributed.

Selection of Appropriate Multivariate Statistical Procedure

Several analytical methods may be employed to analyze simultaneously one or more independent variables with a control variable and one or more dependent variables. It has been argued that multivariate analyses are appropriate to education, since there are numerous variables impacting simultaneously on educational achievement and learning. Multivariate techniques, such as multiple regression analysis, canonical correlation, discriminant analysis and factor analysis are logical extensions of univariate techniques.

Multiple Regression Analysis

Multiple regression analysis uses the principles of correlation and regression to predict the presence and extent of association between two or more independent variables and one dependent variable. The calculations reveal the "goodness" of prediction and use the best linear combinations of all independent variables to account for the position of variance of the dependent variable which is attributable to the independent variables, collectively.

Simultaneous Estimation of Production.-- The fundamental prediction equation is: $Y' = a + b_1X_1 + \ldots + b_kX_k$ where there are k independent variables (X) and k regression coefficients(b). The intercept constant a is the point where the regression line intercepts the Y axis. The correlations between each independent variable and Y determine the slope of each regression line. The slope regression coefficient, b. indicates the change in Y when a change of one unit of X occurs.

In simple regression, n observations of one independent variable (X) are plotted against n observations of the dependent variable (Y) and a regression line is placed as close to all plotted points as possible. It represents the regression of Y on X. The value of a regression coefficient may range from -1.0 to +1.0 and is based on the extent to which plotted points deviate from the calculated regression line along the X and Y axes, i.e., deviation from regression. The higher the correlation of X and Y the smaller are the deviations from the linear prediction (regression) line.

In multiple linear regression there is, in effect, a set of linear equations, one equation for each independent variable. The b's in the equation above are determined by finding those b values that minimize the sum of the squared deviations (residuals) about a regression line known as classic least squares regression estimates. Simultaneous linear equations, called normal equations, are produced which contain coefficients of correlation among all independent variables and between the independent variables and the dependent variable along with a set of beta weights (B)

A multiple correlation coefficient index, R, may be calculated. The "highest possible correlation between a least squares linear composite of the independent variables, in essence another variable, and the observed dependent variable R^2 analogous to r^2 in simple regression, indicates the portion of the variance of the dependent variable, Y, due to the independent variables in concert."[173] The value of R^2 or r^2 can be tested by calculating the F statistic to determine whether it could have been expected by chance alone. The F statistic is computationally simple and is based upon a comparison of the regression variance (mean square due to regression) to variance due to error or chance (mean square not due to regression). A t test of regression coefficients, requiring matrix algebra calculations, may also be used. If the regression coefficient deviates significantly from zero as determined by the test, then the particular variable in question associates significantly with the dependent variable when the other independent variables are accounted for.[174]

The least squares solution has the following properties:

1. It is an estimate which minimizes the error sum of squares irrespective of any distributional properties of the error terms.

2. The elements of B (the estimate of B) are linear functions of the observations $X_1, X_2, X_3, \ldots X_n$ and provide unbiased estimates of the elements of B which have the minimum variances of any such

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[173] Kerlinger, op. cit., p. 617.

[174] See Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, Chapters 35 and 36, for a complete discussion of multiple regression and other multivariate methods.

estimates regardless of distributional properties of the errors.

3. If, as assumed, the errors are independent, each distributed normally with mean 0 and variance σ^2, then the estimate B is also the maximum likelihood estimate of B.[175]

Stepwise Estimation of Production.-- As mentioned earlier, the researcher may supply all independent variables for the final regression equation based on a priori judgment. But lacking a clear idea of the nature of the educational production function, one he can elect to utilize stepwise multiple linear regression analysis. Stepwise multiple linear regression may also be employed to reduce the amount of data. Through this type of analysis, the researcher is able to establish a subset of those independent variables which will explain as much variance as possible. The classic least squares estimation technique is employed in this method, and it contains the same properties as those of least squares. Instead of simultaneously estimating the significance of variables, the stepwise procedure selects variables one at a time to determine their relative impact on the dependent variable.

Two basic stepwise approaches are available and may be modified or combined to produce other procedures:[176] forward selection or backward selection. In forward selection the independent variable which has the highest correlation with the dependent variable is chosen as the first variable to enter the regression model. Other independent variables are chosen one at a time in descending order of their partial correlation with the other variable(s) in the equation until all variables are included, or until the additional variance attributable to the inclusion of a variable is insignificant at a prescribed level. In backward selection all independent variables are initially included in the equation, but removed in ascending order of partial correlation until a prescribed level of significance is achieved.

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[175] Stofflet, Frederick, under the direction of Dennis W. Spuck, PROGRAM WISE*LIB.SETSTP (STEPWISE MULTIPLE REGRESSION PROGRAM), (Madison, Wi.: Wisconsin Information Systems for Education, University of Wisconsin-Madison, 1971), pp. 4-5.

[176] *Ibid.*, pp. 6-8, 11-13.

Limiting Multicollinearity.[177] -- As mentioned earlier, the use of factor analysis assists in reducing multicollinearity and, in fact, appears to be the most frequently employed method for accomplishing that goal. In one study when it was found that inputs under the control of the school were intercorrelated, several production functions were estimated in order to obtain a clearer picture of the impact of those controlled variables. Each one contained only one or two of the school controllable variables as well as all of those variables which were not controllable.

Stepwise regression also has been employed to reduce multicollinearity. One study employed the stepwise procedure after factor analysis to eliminate some of the clustered variables from a regression model. Stepwise regression, however, can create uncertain interpretations of the significance of inputs since perfect orthogonality between independent variables rarely exists. When there is a correlation between independent variables, they also share some of the common variance.

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[177] VARIABLES RELATED TO STUDENT PERFORMANCE, p. 60-61.

> Entry of only one of a group of intercorrelated inputs into an otherwise fully specified model makes it impossible to attribute the estimated relationship solely to the input of interest; since its apparent effect on the dependent variable may not indicate with certainty a direct influence; it may be instead serving as a proxy for another input which does affect the dependent variable.[178]

Critics of the Coleman study, which employed stepwise multiple regression, were quick to point out its inappropriateness when interdependencies exist among independent variables.

> When the explanatory variables X_1 and X_2 are highly intercorrelated with each other as are background characteristics of students and the characteristics of the schools they attend, the addition to the proportions of variances in achievement that each will explain is dependent on the order in which each is entered into the regression equation.[179]

Although R, R^2, and regression coefficients remain the same, the contribution of each independent variable to the total variance will change depending on its order of entry into the equation. Coleman's findings, which stressed the importance of students background variables and minor significance of school variables, were based on the introduction of student background variables into the regression equation before school variables.

To avoid this problem, some critics suggest eliminating insignificant variables from a regression equation on the basis of an earlier estimation of a production function and then conduct a simultaneous estimation of variable significance using the variables remaining from the earlier estimation.[180] Bowles and Levin emphasize that when the purpose of variable estimation is to make educational policy decisions

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[178] Ibid., p. 61.

[179] Samuel Bowles and Henry M. Levin, "The Determinants of Scholastic Achievement-An Appraisal of Some Recent Evidence," JOURNAL OF HUMAN RESOURCES, 3 (Winter, 1968), 15.

> the relevant comparison is one between the expected gains from changing particular aspects of the child's learning environment and the relative costs (broadly construed) of programs designed to effect changes ... The task of statisticians and educational researchers should be directed towards estimating the structural parameters of an equation representing a learning process, with particular attention given to those variables which are subject to social or individual control.[181]

Correlation Coefficients.-- Closely associated with regression coefficients in multiple linear regression are correlation coefficients. In simple regression, the slope of the regression line is the correlation coefficient between the independent and dependent variable after an adjustment is made when the magnitude of two variables is different. Although the correlation coefficient and its square indicate the strength of a relationship and the explained variance, it is regression analysis which can provide information on productivity, i.e., the expected change in output from a change in input level.

Whereas a zero order correlation represents a simple relationship between two variables with no controls, partial correlations between two variables are obtained when the suspected impact of other independent variables on a dependent variable is controlled.

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[180] Samuel Bowles and Henry M. Levin, "More on Multicollinearity and the Effectiveness of Schools," JOURNAL OF HUMAN RESOURCES, 3 (Summer, 1968), 399.

[181] Ibid., 400.

Multicollinearity will operate in this case.[182]

Werts and Linn have shown how one can select a method of regression which will support one's hypothesis about the relationship between two variables. The methods from which one may choose are:

1. The partial correlation between the school variable and the output, controlling input variables, i.e., student characteristics at the time he enters the system;
2. The proportion of variance the school variable adds to prediction after all input variables have entered in a stepwise regression routine;
3. The part correlation between the school variable and the output with input variables partialed out of the output. This part correlation is obtained by predicting the output solely from the input to obtain an "expected" output and then correlating the school variable with the residual (i.e., the actual minus the "expected") output; and
4. The standardized partial regression (i.e., beta) weight of the output on the school variable, when both input and school variables are in the regression equation. The squared beta weight is also used as a "unique" contribution to variance.[183]

Gordon[184] suggested that when control variables are introduced into a multiple regression to partial out the impact of those variables from other independent - dependent variable relationships, the theoretical context for such an action should be specified. If a control variable is nearly identical with a variable in the zero-order relationship, controlling for it will partial out the zero-order relationship. Although, for example, two variables are equally valid indexes of SES, they maintain different properties and significance. Partialling out should imply distinctness between the control and zero-order variables, and not whether a relationship can "survive the application of any conceivable control." Gordon discussed the major ways in which the "partialling fallacy" can be misleading.

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[182] VARIABLES RELATED TO STUDENT PERFORMANCE, pp. 66-7.

[183] Charles E. Werts and Robert L. Linn, "Analyzing School Effects: How to Use the Same Data to Support Different Hypothesis," AMERICAN EDUCATIONAL RESEARCH JOURNAL, 6 (May, 1969), 439-40.

[184] Robert A. Gordon, "Issues in Multiple Regression," AMERICAN JOURNAL OF SOCIOLOGY, 73 (March, 1969), 592-616.

Each method of regression analysis allows for an examination of a particular subset of important relationships between variables. It is the misunderstanding of the purposes and limitations of these methods, and the conclusions made and inferences drawn from the use of these methods in particular research activities, which result in criticism of regression analysis.

Path Analysis[185]

The technique of path analysis attempts to go beyond the simple examination of regression coefficients. To do so, path analysis requires a prior diagrammatic interpretation of suspected causal relationships between variables. The analysis, however, does not deduce causal relationships. The diagram provides a framework for statistical analysis using correlation and regression methods. The independent-dependent relationships depicted among a set of variables are assumed to be linear, additive, and asymetrical (for example, see Figure 5.18). A dependent variable is influenced by a combination of other variables. Residual variables are used when the determining variables do not completely account for the dependent variables. Arrows indicate the direction of influence. Two-headed curved arrows indicate that the relationship between two variables is not being analyzed. The magnitude of each variable is expressed on an interval scale. Some variables may not actually be measured and some may be "true" hypothetical variables rather than measurable proxies. A factor may represent a cluster of variables. The values of path coefficients (p) are entered onto the diagram as are the correlation coefficients (r) in the case of bidirectional correlations (e.g., X_1 and X_2 in Figures 5.18). The equation system representing production functions is as follows:

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[185] This presentation of path analysis is abstracted from a discussion by Otis Dudley Duncan, "Path Analysis: Sociological Examples," THE AMERICAN JOURNAL OF SOCIOLOGY, 72 (July, 1966), 1-16.

$$X_3 = p_{32} X_2 + p_{31} X_1 + p_{34} R_u,$$
$$X_4 = p_{43} X_3 + p_{42} X_2 + p_{41} X_1 + p_{44} R_v$$
$$X_5 = p_{54} X_4 + p_{53} X_3 + p_{52} X_2 + p_{51} X_1 + p_{5w} R_w;$$

> where the first subscript identifies the dependent variable and the second subscript identifies the variable which has the direct effect.

Residuals are assumed to be uncorrelated with each other and with any of the determining variables in the equation. There are uses, however, for intercorrelated residuals. Although feedback loops are not represented, there are ways of handling them (which go beyond the purposes for this presentation).

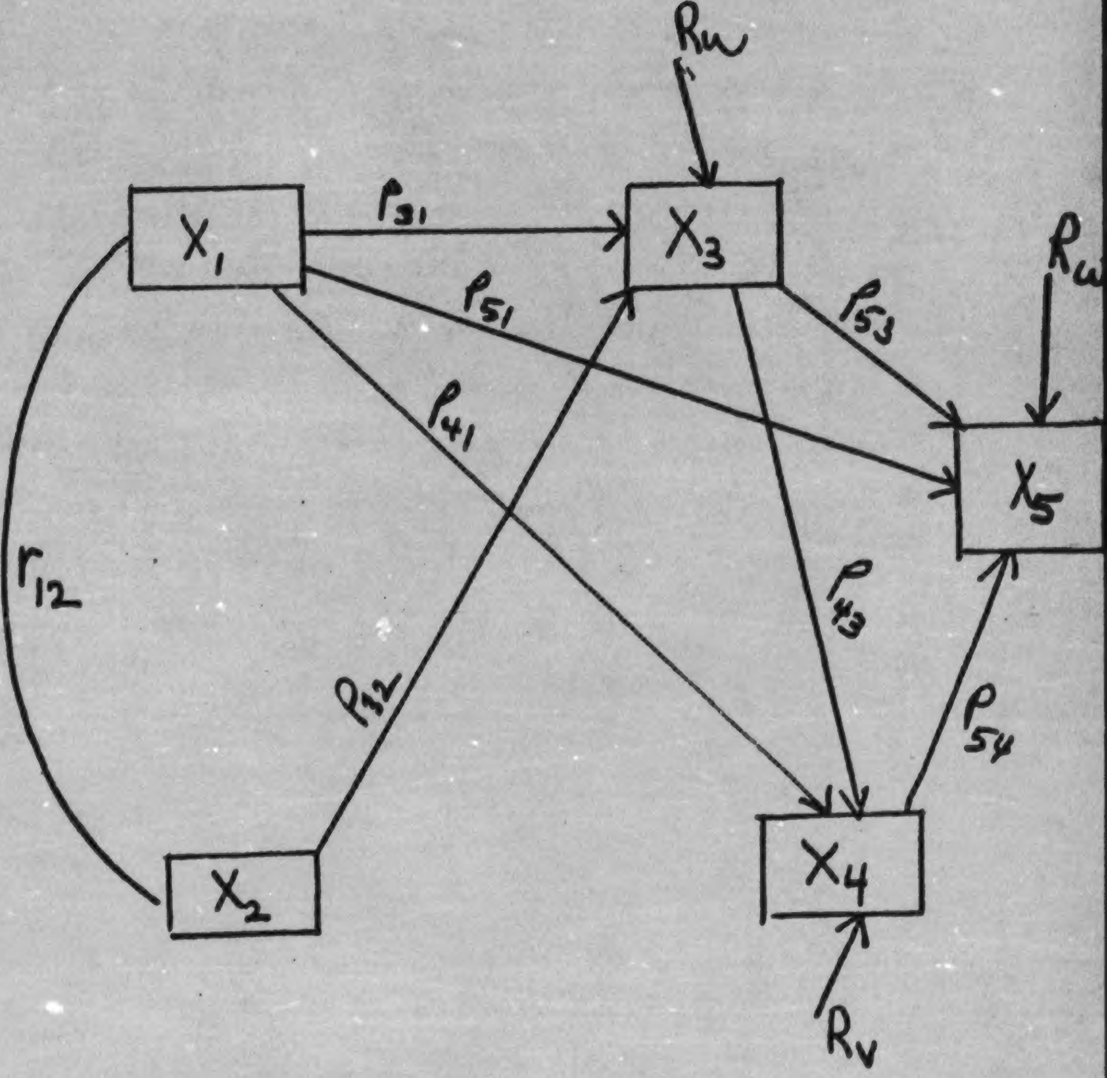
Ru
X1
X3
X2
X4
X5
Rw
Rv
p31
p51
p53
p41
p43
p32
p54
r12

Figure 5.18--A Causal Model for Path Analysis

Source: Otis Dudley Duncan, "Path Analysis: Sociological Examples," THE AMERICAN JOURNAL OF SOCIOLOGY, 72 (July, 1966), 4.

A pair of variables are correlated by examining the paths leading from their common antecedent variables. The manipulators used to derive the correlation between a pair of variables follows from the basic theorem of path analysis, that is,

$$r_{ij} = \sum_{q} \beta_{iq} r_{jq}$$

> ; where i and j represent two variables and the index q runs over all variables from which paths lead directly to X_i.

The resulting correlation represents the sum of a single direct path and all the indirect connections of several compound paths. The equation above represents normal regression equations for variables in standard form. A sequence of regression analyses comprises path analysis such that p equals the beta coefficients obtained from regression calculations. Those hypothesized paths (value of p) which turn out to be insigifnicant may be eliminated and, in turn, all the regressions are recalculated.

Path analysis is essentially regression analysis based upon internally consistent explicit assumptions of cause and effect and uncorrelated residual factors. This procedure allows for the calculation of important indirect effects which would be useful in examining models of school learning. An indirect effect, for example, of X_2 on X_5 would be r_{52}-P_{52}. The calculations can potentially reveal a situation wherein the direct effect of one determining variable on a dependent variable is greater than another, but the reverse may be true of their indirect effects. When an attempt is made to "explain" the correlation between two dependent variables from a set of independent variables, partial correlations may be employed. Path analysis may also be employed to explore whether or not there is a basis for the causal relationships depicted, for in the diagram adjustments may be made if relationships are found to be insignificant.

Assessing Regression Data and Equations

In an evaluation of regression analysis, the assumptions which underlie regression play a central role. The goodness of the data used in specifying a regression equation and the residuals from regression analysis assist in determining the adequacy of the model. This presentation follows a discussion of the subject by Quilling.[186]

The Assumptions Underlying Regression.-- Tukey has cautioned that the data obtained in educational research may be useful even though it is only an approximation of reality and "our formed hypothesis and assumptions will never be broad enough to encompass actual situations."[187]

With respect to the analysis of data, it is assumed that the model being fitted is correct in that the estimates are unbiased and variance is minimum, random error does not exist in the observations of the independent variable(s), and relationships between the independent and dependent variables are linear. Linearity is impaired where there is error in the measurement of the independent variables. Errors are (1) random with mean zero and variance σ^2, (2) uncorrelated, and (3) normally distributed. Thus from the standpoint of (2), observations of Y are uncorrelated. Assumptions (1) and (2) provide for the use of the least squares method, obtaining confidence regions and conducting tests of significance.

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[186] Quilling, "A Data Analysis Approach," pp. 29-45.

[187] J. W. Tukey quoted in Ibid., p. 31.

The Goodness of Data.-- The data obtained from observations and used in regression equations affect the variance of the estimates of parameters in that the variance of estimate is (1) directly proportional to the variance of the data, (2) inversely proportional to the number of observations, (3) inversely proportional to the scale factor, and (4) directly proportional to the correlation between the observations of an independent variable. It is suggested that before obtaining a regression equation, the data should be examined from the standpoint of these four relationships. The balance of observations in the design matrix is assessed through a graph or cross-tabular display, followed by elimination of extreme data points or at least a notation. The size of the experimental error is the mean square error for replication. Correlations are examined between independent variables and between each independent and dependent variable. A decision to eliminate one independent variable which is highly correlated with another may follow. Insignificant or high correlations between an independent and dependent variable will be cause for eliminating a variable or entering it into the regression equation first.

Evaluation of the Equation.-- The regression equation's general sufficiency is assessed by examining unaccounted for variations in the data. Summary statistics available in computer programs for regression analysis are indices of fit (residual analysis). In a correct model, the difference between the observed and predicted value of the dependent variable (residual) represents pure error. If the model is incorrect, the residual represents error plus bias. The bias is then reflected in regression coefficients (i.e., b's will be biased estimates of B's).

Several techniques of residual analysis involving plots on a graph are suggested:

1. Studying the error distribution pattern to determine whether the normality assumption has been satisfied;
2. Plotting residual against expected observations to reveal constancy of variance and whether the equation is linear;
3. Plotting residuals against independent variables singly or jointly to also reveal constancy of variance and whether the equation is linear;
4. Plotting residuals against factors external to the regression model to determine whether they should be included; and
5. Inspecting the error distribution pattern to spot and deal with extreme residuals (outliers), which result in aberrant behavior in other residual photos.[188]

When normality or linearity is absent, a statistical model other than linear regression may be more appropriate.

Canonical Correlations

The use of canonical correlations in educational research has been limited but has recently been applied by both Lohnes and Cooley.[189]

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[188] Ibid., pp. 40-45.

[189] Lohnes, PLANNING FOR EVALUATION, pp. 72-77; Cooley, "Methods of Evaluating School Innovations," pp. 10-15.

With the advent of computer programs for statistical analyses, the complex calculations required are facilitated. Canonical correlation analysis extends multiple regression analysis to situations where sets of independent variables are related to sets of dependent variables which are measured on an interval scale. Multiple regression applies to use with only one dependent variable. Using the least squares method, a canonical correlation (R) is derived from a linear composite of the independent variables (independent vector) and of the dependent variables (criterion vector). As regards the particular set of data employed, the correlation will always be the maximum possible. Regression weights are derived for independent and dependent variables alike to determine the relative degree of association and the greatest contribution to the canonical correlation. The total proportion of generalized criterion variance accounted for by canonical correlation is calculated.[190]

Canonical analysis has been applied to relate each of several sets of independent variables to a set of dependent variables (e.g., cognitive and noncognitive measures of learning). Thus, more than one canonical correlation may be obtained where there is more than one source of canonation in two sets of variables. In one study a host of environmental and other variables were found to relate to both a set of cognitive learning indicators and a set of noncognitive learning indicators.[191] A matrix of all variables reveals all possible canonical correlations and intercorrelations of the predictors.

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[190] Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, pp. 651-53.

[191] H. Walberg cited in Ibid., pp. 653.

In addition to the canonical correlation between variable sets, one can estimate the degree of variance overlap between two measurement vectors (redundancy coefficient).[192] It answers the question, "how much dependent variable variance is explained by the factors of the independent variable?"

Stepwise canonical analysis is available. In this case each set of independent variables enters the model one at a time as in stepwise multiple regression. The same limitations exist when there are intercorrelations between sets of independent variables which gives an advantage to the set(s) which enter the equation first. "Stepwise modeling only makes sense when there is a strong *a priori* agreement for a specific ordering of the set of independent variables."[193]

Discriminant Analysis

Discriminant analysis may be considered a special case of canonical correlation when, in the present case, one or more dependent variables are measured on a nominal scale, i.e., a dependent variable that represents group membership.[194] It operates when only one dependent variable is in the model, but it must be nominally measured,[195] and is closely related to multiple regression when there are two groups within which to classify members. Other methods are used when classification is into more than two groups.

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[192] Lohnes, PLANNING FOR EVALUATION, p. 72.

[193] *Ibid.*, p. 77.

[194] *Ibid.*, p. 72.

Through the least squares method, discriminate analysis can predict the "correct" group membership in calculating the "best" composite score. The higher the total variance, the better the equation is in predicting group membership.[196]

One may calculate the variance in the taxonomic criterion variable attributable to one independent variable or to a set of independent variables. Stepwise discriminant analysis was applied in two research studies to predict high and low district and elementary school productivity.[197] In one study, independent variable problem sets were labeled as student, school, and administrative decision making -- nondecision making related. A maximal mix of independent variables within each problem set was predicted and the amount of variance explained by the variable was calculated.

Analysis of Covariance

Analysis of variance is a statistical tool employed in situations where the effect of one or more experimental factors on equated subjects (by random assignment) is tested. Analysis of covariance combines regression and analysis of variance (i.e., multivariate analysis of variance with covariance adjustment for regression of a dependent variable on a set of independent variables comprising a control variable). It is useful when subjects are not equated, such that nuisance or "matching" factors must be introduced into an experiment to control for other influences on a dependent variable. It has been widely used in curriculum research. Thus multivariate analysis of covariance would appear to be an appropriate statistical tool to employ in determining program effectiveness if it were not for several limitations of the method.

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[195] Wolf, EVALUATION IN EDUCATION, p. 224.

[196] Kerlinger, FOUNDATIONS OF BEHAVIORAL RESEARCH, pp. 650-51.

[197] Scott N. Rose, "A Study to Identify Variables to Predict Local School District Productivity in Two States," (unpublished Ed.D. dissertation, University of Florida, 1972); Carl J. Daeufer "A Study to Identify Variables which Predict Elementary School Productivity," (unpublished Ed.D. dissertation, University of Florida, 1972).

The limitations relate to the requirements of the model. Werts and Linn[198] asserted that, where school and non-school inputs are correlated, the assumption of independence between treatment and covariate in analysis of covariance is violated. Lohnes[199] added additional concerns. As a result of the statistical procedure, one can conclude whether or not there is a "significant difference" due to educational treatment after covariance adjustment. It does not demonstrate a production function, for it does not indicate the strength or the nature of the regression of the dependent variable(s) on the control. The correlation matrix for the residual is not known. The variance due to non-treatment effects has usually been significant but is unexplained when this method is used.

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[198] Werts and Linn, AMERICAN EDUCATIONAL RESEARCH JOURNAL, 445.

[199] Lohnes, PLANNING FOR EVALUATION, pp. 69-72.

On the other hand, factor analysis and canonical correlation tell

> what variance is associated where, what the dimension ability of association is for each explanatory domain, and what factors or principles of explanation can be employed. It is also significant that when classes are the units of analysis the moments of class distributions can be used as observations in canonical and factor analyses.[200]

Curvilinear Regression[201]

Of all the input-output studies reviewed by Alkin and his associates, only one was found which modified a multiple regression model and utilized curvilinear regression to specify a production function.[202] It may be that a linear function may not be the best predictor of output. A single predictor polynomial regression equation would take the form:

$$Y=a+b_1X_1+b_2X_1^2+b_3X_1^3 + \ldots+b_{10}X_1^{10}$$

The strength of curvilinear relationship is the proportion of variance in Y accounted for by X_1 but not by linear regression (b_1X_1). Using the sum of squares rationale, deviations from linear regression may be calculated and when adjusted for error provide the elements of an F test for the existence of a curvilinear regression.

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[200] Ibid., p. 70.

[201] See William L. Hays, STATISTICS, (New York: Holt, Rinehart and Winston, 1963), pp. 539-62, for a complete discussion of the model, test, correlation ratios, and graphic shape of curvilinear regression.

[202] Marvin C. Alkin, Richard Glinski and Robert Winiger, PRELIMINARY ANALYSIS OF DATA FOR A SECONDARY SCHOOL INPUT-OUTPUT MODEL CSE Report No. 42, (Los Angeles: Center for the Study of Evaluation, UCLA Graduate School of Education, 1969).

In the single study cited above, the researchers estimated the number of single variable relationships out of 137 examined. They restricted their fits to arc-shaped (quadratic) and S-shaped (cubic) curves to determine if enough nonlinear associations were present to alter the multiple regression model. The relationship found were:

None	Linear	Quadratic	Cubic	Total
86	33	5	13	137

On the basis of their findings adjustments were made. A polynomial regression computer program was utilized for the calculations.

Display the Results from Costs and Effectiveness Determinations Against the Evaluative Criteria

This section deals with how best to communicate cost and effectiveness data so that it is clearly understandable to both generalists and specialists. Several forms of display are described and illustrated.

Elements of a Display of Effectiveness

In specifying the essential inputs to school district planning, Temkin[203] suggested the elements of effectiveness which should be displayed for purposes of program evaluation. Values in the form of weights must be assigned to each program objective, for if objectives are unweighted, it will be implied that they are of equal importance. Typically, there follows a listing of activites which are intended to lead to the achievement of objectives. Temkin would use, however, cognitive blocks in place of activities, since "experience indicates that the concept of 'activity' as a discrete element of the system, which can be isolated in terms of responsibility and cost, does not lend itself to the study of cognitive sub-systems."[204] A set of activity coefficients is structured which estimates the potential relative importance of each activity on each objective. Subsequently, performance criteria are defined for each activity (cognitive block). The observation of outcomes is translated into a performance index which ranges from 0 to 1.0.

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[203] Sanford Temkin, "Comprehensive Planning for School Districts," (from the proceedings of the symposium on PLANNING AND MANAGING CHANGES IN LOCAL SCHOOL DISTRICTS, Sponsored by the American Educational Research Association, Minneapolis, Minnesota, in March, 1970), pp. 6-8.

Carpenter and Rapp depicted the elements of effectiveness for an entire school district by specifying effectiveness for each class utilizing a program element. (see Figure 5.19).

Elements of a Display of Costs

Costs have usually been tracked by traditional line-item. Where this is the case, line-items can be crosswalked into overall objectives and individual activities or cognitive blocks (see section on Determine the Cost of Each Alternative).

Display of Results

Wolf[205] reviewed the three ways in which evaluation studies can be communicated to others: verbal, tabular, and graphic displays.

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[204] Ibid., p. 7.

[205] Wolf, EVALUATION IN EDUCATION, pp. 234-42.

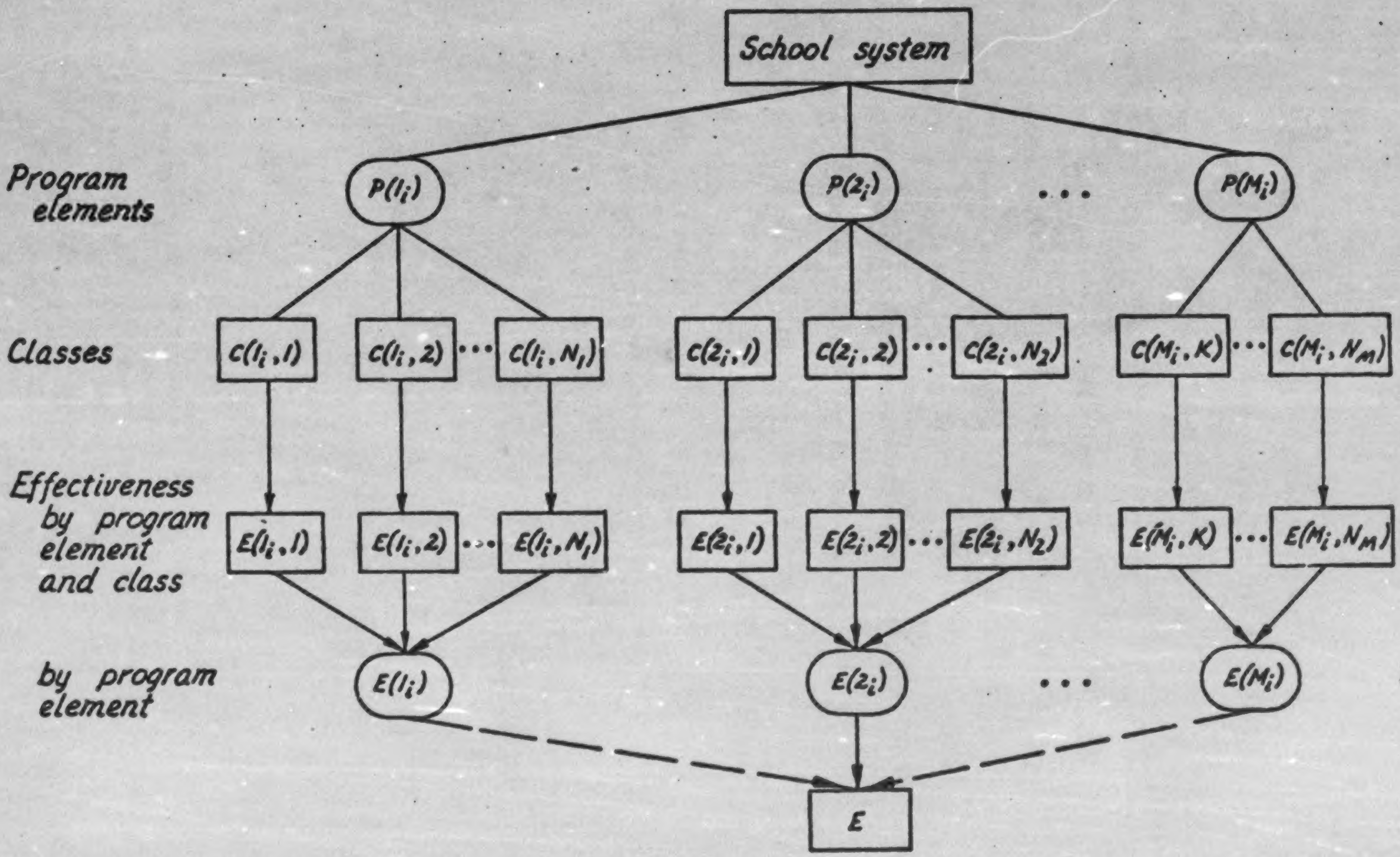
School system
Program elements
P(1_i)
P(2_i)
. . .
P(M_i)
Classes
C(1_i, 1)
C(1_i, 2)
C(1_i, N_1)
C(2_i, 1)
C(2_i, 2)
C(2_i, N_2)
C(M_i, K)
C(M_i, N_M)
Effectiveness by program element and class
E(1_i, 1)
E(1_i, 2)
E(1_i, N_1)
E(2_i, 1)
E(2_i, 2)
E(2_i, N_2)
E(M_i, K)
E(M_i, N_M)
by program element
E(1_i)
E(2_i)
. . .
E(M_i)
E

Figure 5.19--The "Effectiveness" of a District

Source: M. B. Carpenter and M. L. Rapp, "The Analysis of Effectiveness," in Sue A. Haggart, et al., PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, (Santa Monica, CA: Rand, 1969), p. 136.

In the review, he suggested that for the general reader, the use of technical terms should be minimized and that technical points should be included in footnotes and appendices.

A table of summary statistics is necessary and includes such values as means and standard deviations. Pearson[206] suggested the use of tabular displays when measures of cost, effectiveness, or both between two or more alternatives are incommensurate. (see Figure 5.20). Evaluative criteria in decreasing significance represent the columns and the alternatives represent rows. The alternative which best accomplishes the most significant criterion is listed first. This allows for an easy examination of comparative results and will also assist in eliminating a sizeable number of alternatives and causing a more careful examination of the major competitors. Kazanowski[207] suggested that when basic differences between alternative systems are relatively minor, the valid expression between them may be a single parameter. Those factors relevant to goals and objectives should be emphasized to provide a measure of manageability. A table may be used to display effectiveness information by student ability and socioeconomic environments. Since these factors are not controled by the school, they can be included in a definition of program element. Differences can be accounted for by grouping test results of students (stratifying) by socioeconomic and ability levels. Thus these results may be displayed as in Figure 5.21.

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[206] Pearson, "Study of Cost-Effectiveness," p. 56.

[207] Kazanowski cited in Ibid., p. 58.

COST TABULAR DISPLAY

	COST					
		DOLLARS PER NO. YEARS			PERSONNEL REQUIRED	MATERIAL REQUIRED
ALTERNATIVE DESIGN	TOTAL	RESEARCH & DEVELOP	INITIAL/ ACQUISITION	OPERATIONAL		
X Y Z						

EFFECTIVENESS TABULAR DISPLAY

	EFFECTIVENESS				
ALTERNATIVE DESIGN	DEGREE 1	DEGREE 2	DEGREE 3	DEGREE 4	DEGREE 5
X Y Z					

Figure 5.20--Tabular Display Technique Example

Source: Robert Hardy Pearson, "A Study of Cost Effectiveness Analysis With Implications for Instructional Decision making," (unpublished Ph.D. dissertation, Syracuse University, 1972), p. 57.

Item		Socioeconomic Area			
		1	2	3	4
		H X Y Z[b]	H X Y Z	H X Y Z	H X Y Z
		M M M M[c]	M M M M	M M M M	M M M M
School 1	Class 1				
Grade 1	Class 2				
	Class 3				
	.				
	.				
	.				
	N_1				
School 2	Class 1				
Grade 1	Class 2				
	Class 3				
	.				
	.				
	.				
	N_2				
School N_s					

[a] Mean scores and measure of variability for each class would be displayed in body of table.

[b] H = honors; X = above average; Y = average; Z = below average.

[c] M = district-wide mean.

Figure 5.21--Test Results for a Program Element

Source: M. B. Carpenter and M. L. Rapp, "The Analysis of Effectiveness," in Sue A. Haggart, et al., PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, (Santa Monica, Ca.: Rand, 1969), p. 128.

Figure 5.21 provides a comparison of a class mean with the overall mean and reveal the relative achievement of each. The meaningfulness of a class average is indicated by the variability within the class. This displays will also reveal program element effectiveness by class, socioeconomic class and ability after pre and post test data are compared.

Graphs

Whereas tabular displays are most appropriately placed in appendices, graphic representations should be emphasized. Vertical or horizontal bar graphs can compare performance scores for each alternative. Figure 5.22 demonstrates how pretest and posttest information may be incorporated on the same graph for four distinct treatment groups of students on eight subtests.

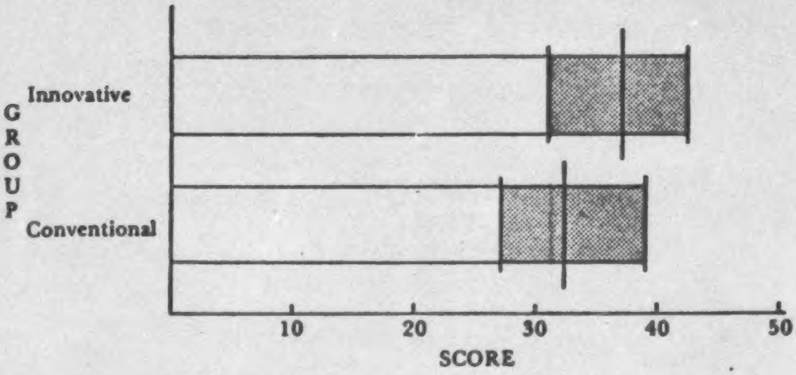
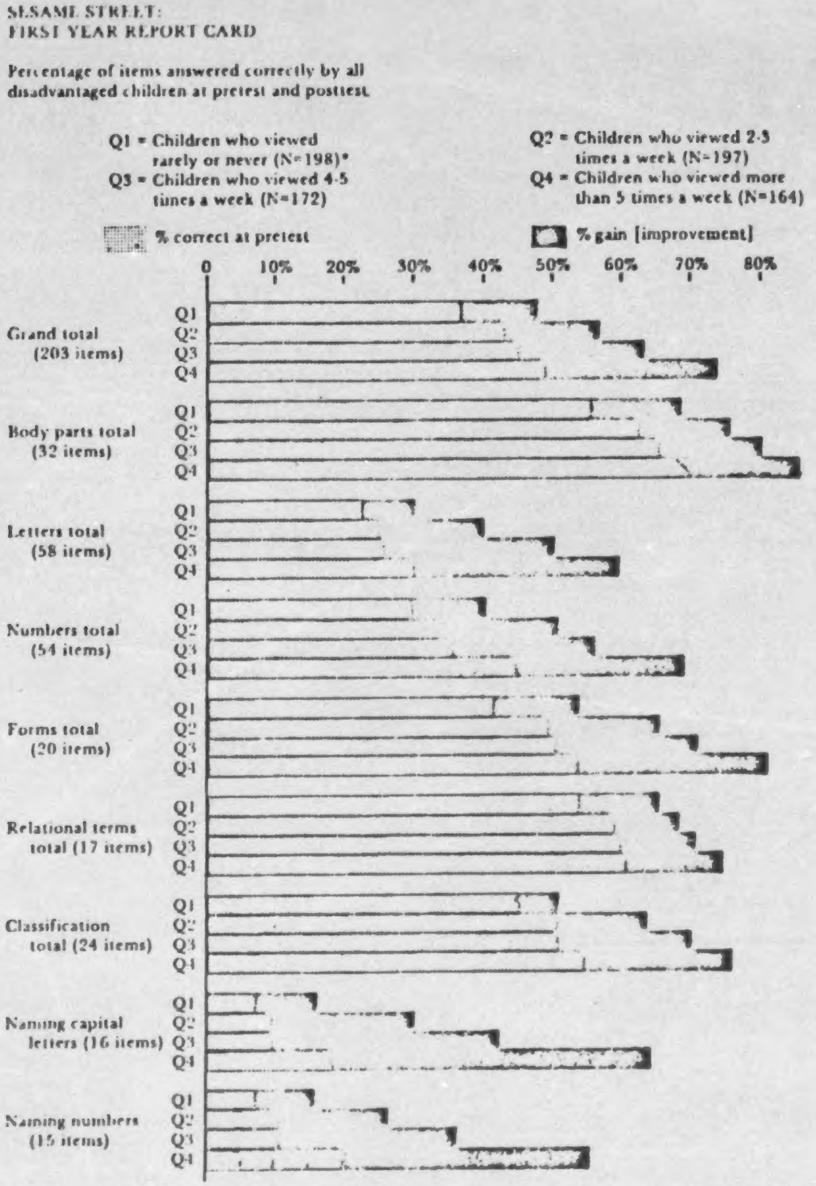


Figure 5.22--Performance Levels (means P_{25} and P_{75}) for Innovative and Conventional Groups

Source: Richard M. Wolf, "Data Analysis and Reporting in Evaluation," in W. James Popham, ed., EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, Ca.: McCutchan, 1974), p. 239.



Source: Educational Testing Service

*Number tested

Note: From the *New York Times*, November 5, 1970, p. 55.

Figure 5.23--Graphic Presentation of Both Pretest and Posttest Results

Source: Richard M. Wolf, "Data Analysis and Reporting in Evaluation," in W. James Popham, ed., EVALUATION IN EDUCATION: CURRENT APPLICATIONS, (Berkeley, Ca.: McCutchan, 1974), p. 238.

Verbal

The presentation of results should provide space for the evaluation of objectives, procedures, and results without technical impediments. This sector contains an interpretation of information contained in tables. When a test of statistical significance between means and a test of educational significance (intraclass correlation on w^2) plus one's judgment have been performed, they should also be reported. Information pertaining to variability, such as the significance or importance of differences between groups contained in an analysis of variance summary table, should be reported in the text. A statistical test of the proportion of students achieving the criterion level also is available.

State the Non-quantifiable and Uncertainty Factors

Many factors, in addition to the directly estimated cost and effectiveness data, will affect a decision maker's choice of programs to implement or continue to operate. These uncertainties are factors which would affect cost and effectiveness data if they could be qualified or are external to the cost and effectiveness dimensions. The review of literature which follows focuses on the nature of such uncertainties and suggests ways to account for them.

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[208] Wolf, EVALUATION IN EDUCATION, pp. 234-42.

Analyses and Uncertainties

Decisions are by nature clouded by a degree of uncertainty and good through analysis should recognize the presence of uncertainty. One of the analyst's tasks is to identify the presence and evaluate the impact of those uncertainties.[209] Haggart asserted that the role of analysis is not to provide a single answer, but rather "to increase (understanding of) the nature of the problem, the consequences of different solutions, and the feasibility of alternative courses of action."[210] Fisher suggested that, in light of the many intangible considerations, e.g.s, political, psychological, and sociological, in no case should it be assumed that the result of analysis is a cut-and-dried decision. All considerations, especially non-quantitative ones, cannot be taken into account. Thus, intuition and judgment, as well as analytical data, play a large part in any decision.[211]

Nature of Uncertainties

It may be said that the existence of uncertainties creates a possible range of costs and benefits for each alternative. Thus the range of costs and benefits for one alternative is likely to overlap those of other alternatives.[212]

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[209] Quade, PLANNING, PROGRAMMING, BUDGETING, pp. 252-53.

[210] Sue A. Haggart, "Increasing the Effective Use of Analysis Through Program-Oriented Management," (a paper prepared for presentation at the annual meeting of the American Educational Research Association, Chicago, Illinois, April 3-7, 1972), pp. 1-2.

[211] G. H. Fisher, THE WORLD OF PROGRAM BUDGETING, (Santa Monica, Ca.: Rand, 1966), p. 11.

Pitfalls can be avoided during the analysis. An analyst may attach undue significance to his calculations where he has seen his assumptions as truth. A serious pitfall is an unconscious adherence to a "party line...caused by a cherished belief or an attention bias."[213] Whereas pitfalls are avoidable, inherent limitations exist. Quade and Pearson[214] suggested three major limitations: analysis is necessarily incomplete; measures of effectiveness are inevitably approximate, i.e., statistical uncertainy; and ways to predict the future are lacking. Analysis is necessarily incomplete due to the inevitable time and budgetary constraints. Also one can never really treat all relevant considerations. Immeasurable considerations include intangible and moral judgments. Although measures of effectiveness are approximate and may not be completely realistic, the requirement in cost-effectiveness comparisons is that the data indicate the relative merit of alternatives,[215] or that measure are found which point in the right direction.[216]

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[212] Leonard Merewitz and Stephen Sosnick, THE BUDGET'S NEW CLOTHES: A CRITIQUE OF PLANNING - BUDGETING AND BENEFIT-COST ANALYSIS, (Chicago: Markham, 1971), p. 125.

[213] Quade, PLANNING, PROGRAMMING, BUDGETING, p. 258.

[214] Ibid.,pp. 259-61; Pearson, "Study of Cost-Effectiveness," p. 78.

[215] E. S. Quade, COST-EFFECTIVENESS: SOME TRENDS IN ANALYSIS, AD 650 129 (Springfield, Va.: Clearinghouse for Federal Scientific and Technical Information, March, 1967), pp. 3-4.

[216] Quade, PLANNING, PROGRAMMING, BUDGETING, p. 260.

Seiler[217] distinguished endogenous from exogenous considerations in his discussion of the cost-effectiveness criterion of decision making. Endogenous considerations are those factors which are included in the numerical computation of the cost-effectiveness criterion, whereas exogeneous considerations are external to the cost-effectiveness criterion, not amenable to objective analysis, and unpredictable. They are labelled technological advances, resource availability, political sensitivity, and psychological stimulus. These considerations, in large part, require subjective evaluation. If alternatives which are at varying degrees of developmental advancement or refinement are compared, a projection of the projected progress beyond current technology is required. In addition to the primal benefits (those for which the alternative was developed), collateral benefits may exist now or in the future which will contribute to an alternative's overal merit. This information may be important to decision makers. Whereas the total cost of resources required of an alternative is part of the cost-effectiveness criterion, other alternative requirements may require the consumption of scarce resources which may be difficult to procure. Specifically, resources are human and material as well as financial. Such resources may be unavailable or too costly. In addition, consuming a resource for one purpose eliminates the possibility that it may be used for another purpose, at least concurrently. When there are political overtones to a decision relative to the selection of alternatives, the selection is further complicated. It is those politically tainted situations which require a rational decision based upon the collection of all relevant information to reduce uncertainty as much as possible. Psychological reactions may ensure the development of alternative systems, whether planned or not, which, if negative, may cause the effectiveness of such a development to be neutralized. Had the decision been to choose a less cost-effective alternative, such a reaction might not have followed.

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[217] Karl Seiler, III, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, (New York: Wiley-Interscience, 1969), pp. 96-101.

Approaches and Techniques to Treat Uncertainties

Some approaches and techniques have been proposed which are directed at assisting in the reduction of uncertainties caused by nonquantifiable considerations relative to cost-effectiveness. Approaches are available which provide for the systematic and direct use of expert judgment.[218] Although opinions may vary initially, a consensus may be formulated by group exercise ranging from single structured discussion to simulation or an operational game (which is a laboratory simulation whereby experts play the roles of decision makers). "Scenario writing," a term used by military systems analysts, shows the evolution of a future condition from the present. A collection of scenarios can provide insight into the future of alternatives under controllable factors. The Delphi method causes each individual's opinions to be subject to the criticism of other experts without actual confrontation. Information and opinion are exchanged through a sequence of questionnaires, which causes a refinement of subsequent information and opinion feedback from the computation of degree of consensus. In addition to the above approaches, a "decision tree" is an approach which is based upon network theory. It consists of branches that represent alternatives and nodes which represent decision points and probability event points.[219]

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[218] Quade, PLANNING, PROGRAMMING, BUDGETING, pp. 254-56.

Statistical uncertainties have most often been treated by sensitivity, contingency and a fortiori analyses.[220] The results of a cost-effectiveness analysis are sensitive to the assumptions that were made in establishing cost and output estimates. Instead of using expected values as in the original estimates, higher and lower estimates can replace the original estimate to determine how sensitive the results of alternative rankings are to parametric changes. Another consideration is the sensitivity of life-cycle estimates on alternative rankings.

> While sensitivity analysis can add information, it does not in itself produce a ranking of alternatives. Of course, if one alternative has more favorable values of costs and benefits for every set of assumptions, then it is called dominant and it will be recommended.[221]

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[219] Seiler, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, pp. 96-7.

[220] Pearson, "Study of Cost-Effectiveness," pp. 79-80.

[221] Merwitz and Sosnick, BUDGET'S NEW CLOTHES, p. 126.

Contingency analysis is an investigation into the effect of changes in the order of alternative rankings after criteria for evaluating the alternatives are altered or a significant change in environmental conditions is introduced. Thus, results are contingent on changes in one or more conditions. Contingency tables may be prepared which will display the cost-effectiveness of each alternative for any number of changed conditions and sets of assumptions about uncertainties. In *a fortiori* analysis, an examination is made between the two alternatives. Uncertainties are resolved in favor of one alternative to see how the other alternative compares under those adverse conditions. This would apply where tenerally accepted intuitive judgment would favor one alternative over another but may, in fact, be a poor choice. The performance of such analyses contributes to one's understanding of the nature of uncertainties.

Merge Cost and Effectiveness Information into a Decision Framework and Document the Merits of Each Alternative

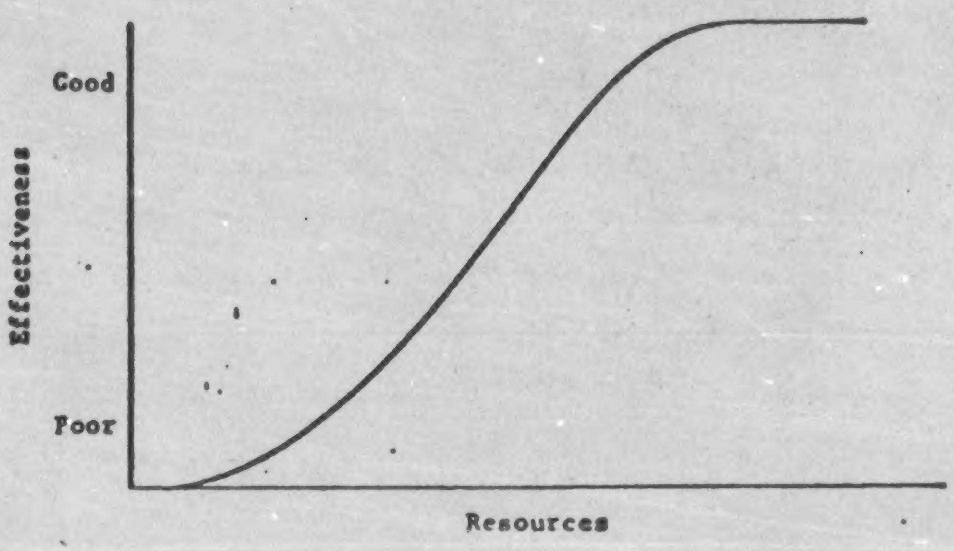
This review provides some guidance into appropriate ways to merge the cost and effectiveness dimensions of educational programs into a framework which will facilitate decision making. In addition to methods of integration, two illustrative frameworks are provided, and guidelines for documentation are outlined.

Model Relationship Between Cost and Effectiveness

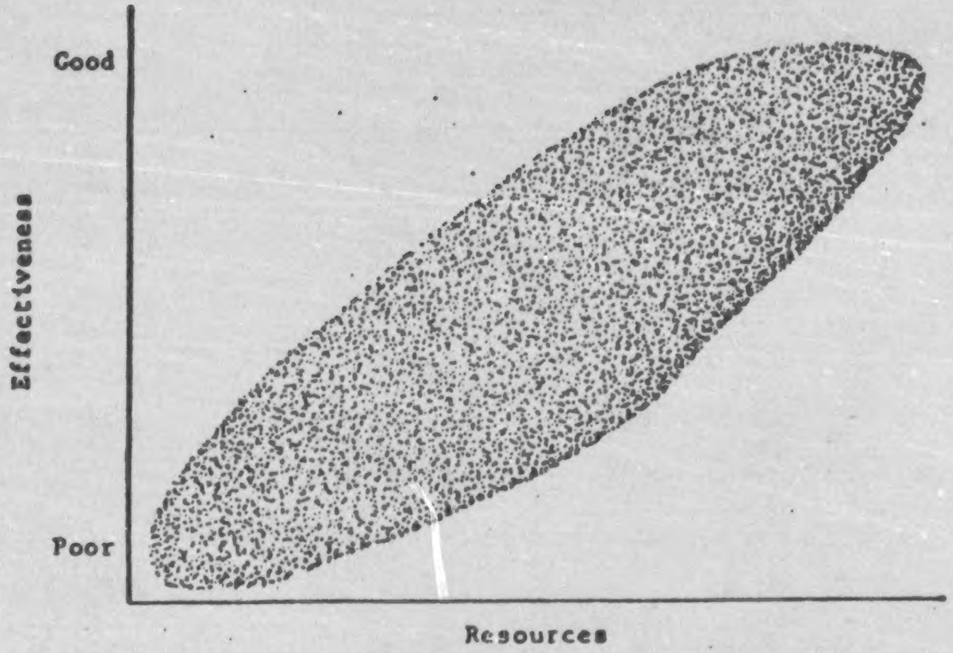
Most researchers perceive a relationship between the amount of resources committed to a project and the effectiveness of that project as in part A of Figure 5.24. The relationship depicted is nearly linear until a point is reached where the addition of resources makes little to no difference. Others would prefer to illustrate the relationship as shown in Part B of Figure 5.24 wherein the association is not mathematically clear cut so that it is difficult to assess exactly where the boundary between good and poor exists. This being the case, precise mathematical tools alone will not suffice.

Frameworks for Cost and Effectiveness Merger

It has been suggested that tabular display or analytical model techniques are available with which to merge cost and effectiveness values into a single common unit. A tabular display of this type is depicted in Figure 5.25. In this illustration a variety of instructional designs are available for in-service employee training. The worth of each design is compared to a set of selection criteria. Economy, as a substitute for cost, and other "output" criteria are combined to give a single numerical evaluation. The alternatives are ranked from 1 (highest) to 6 (lowest) and listed in order of recommended preference. The analytical model techniques shown graphically in Figure 5.26 illustrate that particular procedural process of cost-effectiveness dealing with the merger of cost and effectiveness.



A. A well-behaved relationship



B. A relationship for an educational system(?)

Figure 5.24--Examples of Relationships between Effectiveness and Resources

Source: M. B. Carpenter and M. C. Rapp. "The Analysis of Effectiveness," in Sue A. Haggart, et al., PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, (Santa Monica, Ca.: Rand, 1969), p. 131.

RECOMMENDED INSTRUCTIONAL DESIGN FOR EMPLOYEE TRAINING IN ORDER OF PREFERENCE ACCORDING TO COST-EFFECTIVENESS SELECTION CRITERIA

	SELECTION CRITERIA						
ALTERNATIVE INSTRUCTIONAL DESIGN	ECONOMY	FLEXIBILITY	ADMISSION STANDARDS	EMPLOYEE ACCEPTABILITY	EMPLOYER ACCEPTABILITY	SPEED	TOTAL NUMERICAL EVAL.
DAY-RELEASE COURSES	1	6	5	5	3	6	26
FULL TIME SCHOOL	5	5	4	4	2	1	21
SANDWICH COURSES	4	4	3	3	4	3	21
VOCATIONAL TRAINING	6	1	6	6	1	2	21
BLOCK RELEASE COURSES	3	3	2	2	6	4	20
EVENING CLASSES	2	2	1	1	5	5	16

Figure 5.25--Cost-Effectiveness Analysis Tabular Display Example

Source: Robert Hardy Pearson, "A Study of Cost-Effectiveness Analysis with Implications for Instructional Decision making," (unpublished Ph.D. dissertation, Syracuse University, 1972), p. 70.

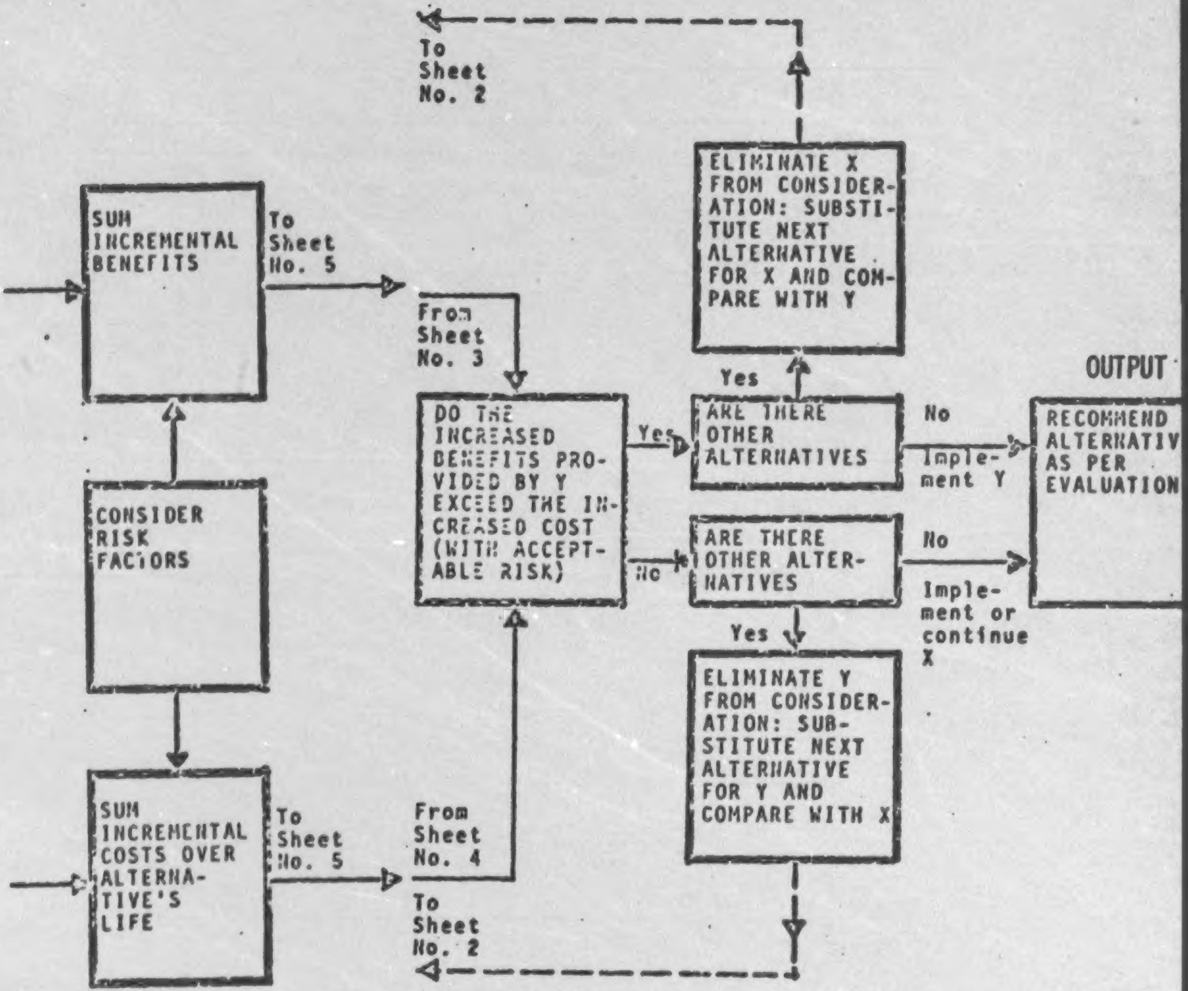

SUM INCREMENTAL BENEFITS
To Sheet No. 5
From Sheet No. 3
CONSIDER RISK FACTORS
SUM INCREMENTAL COSTS OVER ALTERNATIVE'S LIFE
To Sheet No. 5
From Sheet No. 4
To Sheet No. 2
DO THE INCREASED BENEFITS PROVIDED BY Y EXCEED THE INCREASED COST (WITH ACCEPTABLE RISK)
Yes
No
To Sheet No. 2
ELIMINATE X FROM CONSIDERATION: SUBSTITUTE NEXT ALTERNATIVE FOR X AND COMPARE WITH Y
Yes
ARE THERE OTHER ALTERNATIVES
No
Implement Y
ARE THERE OTHER ALTERNATIVES
No
Implement or continue X
Yes
ELIMINATE Y FROM CONSIDERATION: SUBSTITUTE NEXT ALTERNATIVE FOR Y AND COMPARE WITH X
OUTPUT
RECOMMEND ALTERNATIV AS PER EVALUATION

Figure 5.26--Cost-Effectiveness Analysis Analytical Model Example

Source: Robert Hardy Pearson, "A Study of Cost-Effectiveness Analysis With Implications for Instructional Decision making," (unpublished Ph.D. dissertation, Syracuse University, 1972), pp. 74-75.

Appropriate Methods of Merging Cost and Effectiveness

Several methods have been suggested or utilized for integrating cost and effectiveness information, including ratios, mathematical models, productivity per unit of gain, marginal productivity analysis and elasticity of cost-effectiveness.

Ratio and Mathematical Models

The ratio model[222] is an indicator of efficiency. It is simply the division of some effectiveness (output) dimension index by some cost (input) dimension index for an alternative. Thus, $\frac{E}{C}$ = cost-effectiveness figure of merit. The normalization of cost indices, together with normalized effectiveness indices, can provide a quantifiable comparison of cost-effectiveness between alternatives. Another procedure utilizes a planar cost-effectiveness graph as follows:

1. Establish the domain of feasibility by erecting the maximum cost limit ordinate and the minimum effectiveness limit abscissa coordinates.
2. Sweep a vector from the origin through the point that represents the maximum angular sweep possible through any of the points.
3. Determine the coordinate values of the point lying on the highest angular vector and compute the figure of merit.[223]

Stofflet[224] introduced a quantitative model which assumes that all variables included within it are measurable and available. For this reason its application is generally restricted to those school settings which utilize a program planning and budgeting system with a well defined program structure, associated objectives and a grouping of activities to accomplish program objectives. Additionally, a cost accounting system must track the cost per student per activity, and achievement gain scores must have been recorded. A value is placed on the contribution of each activity. The model takes into account a set of value functions (current status) of the individual relative to each objective. The model's equations are formulated for:

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[222] Seiler, INTRODUCTION TO SYSTEMS COST-EFFECTIVENESS, pp. 74-76.

[223] *Ibid.*, p. 76.

[224] Frederick Stofflet, "A Quantitative Model of Evaluation for Use in PPBS," (unpublished Ph.D. dissertation, University of Wisconsin-Madison, 1973).

1. Total benefit to student t of having made a gain relative to a particular objective O;
2. Benefit attained by a student t by involvement in activity A to accomplish objective O;
3. Total benefit of a program P to student t and
4. Total benefit of the entire program P to all students.

Similarly, costs must be accounted for by student over all activities for an entire program and a total benefit-cost (or cost-effectiveness) ratio is attainable for program P. Likewise, the total benefit-cost ratio of activity A over all students is attainable. Consequently, the model may be applied to compare alternative methods' grouping of activities to accomplishing the same set of objectives. When activity costs can be traced by objectives, since in many cases a particular activity may be used to meet more than one objective, then a benefit-cost ratio comparison for objectives is possible.

Productivity Per Unit of Gain

When Levin[225] surmized that the recruitment of verbally able teachers provided a better payoff than the recruitment of experienced teachers, he based his judgment upon the calculation of production function estimates for several teacher characteristics. He associated additional points of student verbal score with each additional unit of teacher verbal score and teacher experience production coefficients. Levin then showed, using a linear production function, the annual dollar return to teachers for specific characteristics, pointing out that it costs the schools approximately $79 to obtain a teacher with an additional year of experience and only $24 to obtain one with an additional point on a verbal score. Finally, he showed the relative (not absolute) cost of improving student achievement by purchasing teacher verbal score and experience. These costs were obtained by applying salary cost coefficients to production coefficients to yield approximate cost for increasing a student's verbal score by one point using teacher's verbal score and alternatively using experience strategies.

Marginal Productivity Analysis and Elasticity of Cost-Effectiveness

Marginal analysis may be employed when the level of a specific resource is either increased or decreased to determine the degree of effectiveness change. When the level and/or composition of a particular program's resource(s) is changed, it may be said that a program alteration is created. Thus, the former level and/or composition of resources may be compared to the latter to yield cost-effectiveness distinctions. Continuous comparisons may be made over time to find a point where additional resources make no substantial impact on effectiveness or where the added gain for the added cost is inefficient when compared to previous cost-effectiveness ratios. In this context, the plotting of cost-effectiveness ratios (see Figure 5.27) will illustrate rates-of-return on investments. It also will illustrate when levels of resources (elements) can profitably be traded. The cost-effectiveness curve in Figure 5.27 indicates that a large decrease in resources for B provides resources for A, since increasing the effectiveness of A does not appreciably decrease the effectiveness of B.

---

[225] Henry M. Levin, "A Cost-Effectiveness of Teacher Selection," JOURNAL OF HUMAN RESOURCES, V (Winter, 1976), 24-33.

In other words, alternatives may be evaluated by examining them with and without a particular resource (element).[226] The elasticity of cost-effectiveness is defined as:

---

[226] Sanford Temkin, "The Elasticity of Cost-Effectiveness: Implications for Public Sector Decision-Making," (paper prepared for presentation at the annual meeting of the American Educational Research Association, New York, New York, in February, 1971), pp. 3-4.

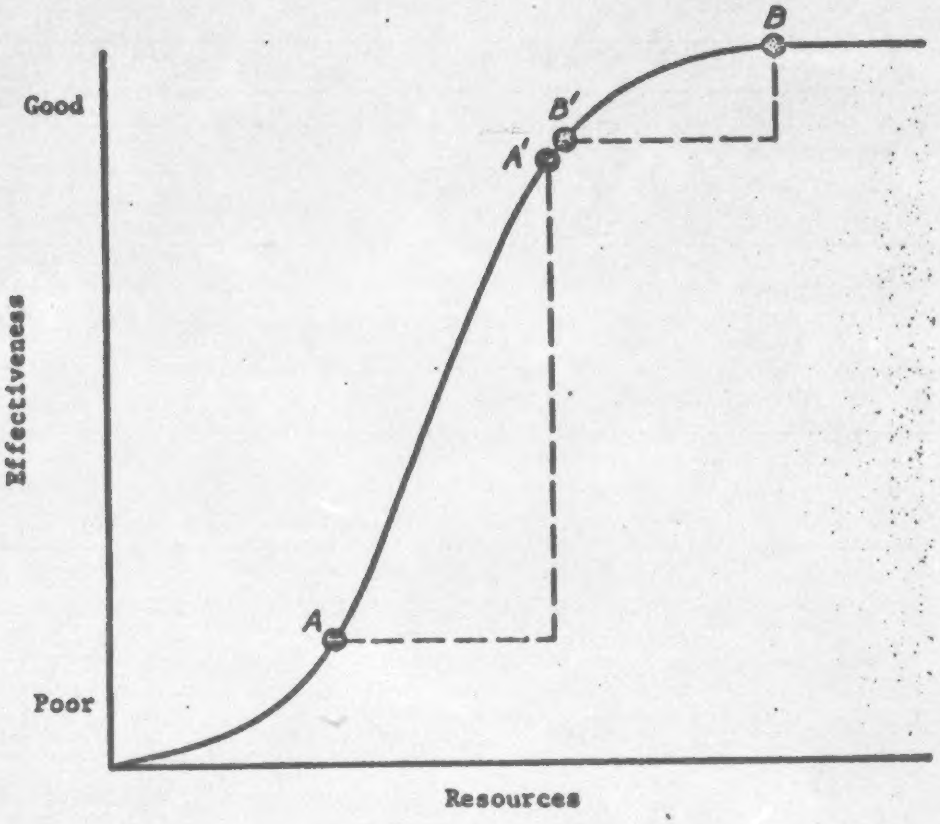
B
Good
B′
A′
Effectiveness
A
Poor
Resources

Figure 5,27--Concept of Rate-of-Return

Source: M. C. Carpenter and M. L. Rapp, "The Analysis of Effectiveness," in Sue Haggart, et al., PROGRAM BUDGETING FOR SCHOOL DISTRICT PLANNING: CONCEPTS AND APPLICATIONS, RM-6116-RC, (Santa Monica, CA: Rand, 1969), p. 139.

$$(E/C)_i = \frac{\Delta E/(E - \Delta E)}{\Delta C/(C - \Delta C)}; \quad \Delta E < E \quad \Delta C < C$$

and where E is the relative effectiveness score for element

E is the combined relative effectiveness score for

M element in the system, $E = \sum_{i=1}^{M} E_1$

ΔC is the cost of element i,

C is the total cost for all M elements. $C = \sum_{i=1}^{M} C_1$

These terms can be rearranged so that the numerator of $\frac{E}{C}$ is the ratio of the effectiveness to the cost of the element under investigation and the denominator is the remainder of all the other elements making up an alternative. If the resultant ratio is 1, the element has not contributed to the averate cost-effectiveness. If the ratio is greater or less than 1, the element has a higher or lower rate of productivity per unit than the remainder of the elements. The formulation is as follows:

$$(E/C)_i = \frac{C\Delta E - \Delta C\Delta E}{E\Delta C - \Delta C\Delta E} = \frac{\Delta E}{\Delta C} \quad \frac{C - \Delta C}{E - \Delta E}$$

$$(E/C)_i = \frac{\frac{\Delta B}{\Delta C}}{\frac{E - \Delta E}{C - \Delta C}} \quad \gtreqless 1, \quad \begin{matrix} C > & \Delta C & > 0 \\ E > & \Delta E & \geq 0 \end{matrix}$$

Decision Criteria and Guidelines for Documentation

Harmon[227] cautioned that a cost-effectiveness index may only allow for a comparison specification of "more" or "less" cost-effective, i.e., an index of relativity. It is not necessary to be precise when the analysis of cost-effectiveness is conducted within one specific instructional system.

It is desirable to obtain an index figure where the exact magnitude is desired then, for instance, if effectiveness is specified as "percentage of total effectiveness," cost figures need to be converted to "percentage of total dollars spent."

In addition to the merger of cost and effectiveness estimates, other relevant information which will make the estimates meaningful must be identified and supplied to decisionmakers.[228] The information should include characteristics of the feasible alternatives, risk factors, and the application of a selection criterion. For example, the selection criterion might read as follows:

> If the sum of incremental benefits in dollars of the new program [instructional design] . . . exceeds its increase in incremental costs [with acceptable risk], then the new program is ranked higher than existing program and the existing program is eliminated from further consideration. If the reverse is true, the existing program is rated higher and the new program is eliminated.[229]

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[227] Paul Harmon, "Curriculum Cost-Effectiveness Evaluation," AUDIOVISUAL INSTRUCTION, 15 (January, 1970), 26, 27.

[228] Pearson, "A Study of Cost-Effectiveness," pp. 76-78.

[229] Institute for Educational Development quoted in Ibid., p. 77.

The alternatives should be rank ordered in accordance with the evaluative criteria. Those alternatives which fail to meet minimal standards could be eliminated from further scrutiny. Those cost-effectiveness values which approximate each other require further scrutiny. The documentation of methods, assumptions and sources is a necessary component of the analysis report, particularly for purposes of replication. Pearson underscored the importance of documenting the following:

1. Specific goals/objectives to be attained;
2. Essential requirements of those goals/objectives along with associated assumptions;
3. Alternative capabilities and associated assumptions;
4. Alternative costs and associated assumptions (learning curves, time, quantities, etc.);
5. Alternative evaluation and associated assumptions (scenarios, criteria, etc.); and
6. Conclusions--the recommended alternative, the limitations, and the associated uncertainty factors.[230]

Summary

Chapter V examined the elements and procedures of cost-effectiveness through a search and synthesis of the literature in order to discover the essential factors within, boundaries of, and relationships between each element and procedure. This information is necessary if a comprehensive analytical model of cost-effectiveness/productivity for comparing educational programs is to be specified.

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[230] Ibid., p. 82.

As a secondary consideration for the review, the literature also contained some guidelines and references to the users of the model as they proceed through it in order to conduct a cost-effectiveness analysis. The chapter was arranged into nine sections which are analogous to the major cost-effectiveness processes. They included:

1. Specify the goals and objectives that the alternative educational programs are to fulfill.
2. Distinguish the alternative programs.
3. Specify evaluative criteria (measures of effectiveness).
4. Specify evaluative criteria (measures) of cost.
5. Determine the cost of each alternative.
6. Determine the effectiveness of each alternative.
7. Display the results from cost and effectiveness determinations against the evaluative criteria.
8. State the non-quantifiable and uncertainty factors.
9. Merge cost and effectiveness information into a decision framework and document the merits of each alternative.

Specify the Goals and Objectives that the Alternative Educational Programs Are to Fulfill

This step requires that the goals, objectives, and competencies which students are to achieve through their involvement in an educational program be outlined. The development of instructional strategies will depend on a conceptual base and a taxonomy for organizing learning outcomes, in addition to the specification of (1) target population to be involved in accomplishing specified goals, objectives, and competencies, and (2) desired performance level. Each objective includes several component parts which identify the nature, condition, and criterion of performance. Since not all objectives are of equal importance, a process for ranking objectives must be established.

Distinguish the Alternative Programs

A common criteria set of characteristics needs to be selected to make resource comparisons between educational programs. This set must balance the potentially conflicting requirements of flexibility and manageability. In addition, it must distinguish different instructional strategies, different classroom interpretations of a specified curriculum, and actual from ideal implementation.

Several taxonomic paradigms were suggested for providing comparative program content and practices and resource information--even to the point of quantifying some descriptors.

Specify Evaluative Criteria (Measures) of Effectiveness

Program measures of student performance may be adopted, adapted, or developed for use on a sample of or total student population involved in program evaluation, but there are a host of problems encountered in utilizing any of the above. Reliable and valid measures of a program's accomplishment are required to reduce or eliminate errors of measurement. Reliability and validity may be estimated in several ways. Tests of performance may assess proficiency, mastery, and understanding of general or specific area of cognition. On the other hand, attitude scales measure thoughts, feelings, perception and behaviors towards a referent or cognitive object. Response on achievement tests and attitude scales may be evoked in several ways.

Norm- and criterion-referenced tests can be used to compare the claims of competing alternatives. In using norm-referenced tests, conceptual problems, such as bias, and operational problems, such as matching educational objectives and test contest (test construction), test validity, and statistical analyses, must be overcome. Whereas the results of norm-referenced testing are based upon a comparison with a previously tested population sample of subjects, criterion-referenced tests examine a student's or group's level of criterion achievement. This type of test is subject to limitations of criterion deficiency and distortion, as are standardized tests. General procedures for test construction and for specifying a minimally acceptable level of performance were referenced.

Specify Evaluative Criteria (Measures) of Cost

One aspect of the analytical process of cost-effectiveness is the conversion of program resource requirements into cost estimates. This is accomplished through the specification of a cost model. This cost model must reflect a definition of what constitutes cost. Recent explanations tend to give cost a broad multidimensional interpretation of opportunity costs to include, for example, monetary, and nonmonetary components. A cost model will be responsive to key qualitative and quantitative differences characterizing program alternatives, including specific elements of time, space, equipment and supplies. A stream of costs running throughout a program's lifetime has research and development, investment, and operating phases.

Determine the Cost of Each Alternative

Cost analyses provide program descriptive data and reveal what kind and quantity of resources are given up for alternative use. The steps in cost analysis generally include the identification of resource restraints, calculation of cost, identification of possible cost variances and verification of completeness. A host of factors can influence and govern costs. Macroeconomic factors include borrowing and investment policies, inflation or deflation, and tax revenue increases or decreases. Local or microeconomic factors of program size and performance characteristics, rate and cumulative number of units of reource procurred, and procurement practices also will govern costs.

The manner in which data are recorded and retrieved will affect the availability of appropriate, accurate and timely cost estimates. In cases where data have been recorded in traditional line-item budget formats, a cost analysis by program will be necessary, which will entail the use of a "crosswalk" technique. In order to compare costs between programs in a manner which will eliminate the influence of some inappropriate microeconomic factors, standard units of measure must be adopted for each input. It may be different for costs incurred in utilizing staff, students, facilities (space), equipment, materials, and supplies. In addition, it may be wise to decontaminate comparison between programs by establishing standard prices for units of resources (comparable replication cost). When the process of determining units of measurement for each resource, indicating cost per resource unit, and specifying the required number of resource units is completed, a cost estimating relationship has been developed.

Two examples of cost analytical structures were provided. One seeks to determine the cost of educational media systems; the other examines the cost of program implementation (specifically Individually Guided Education in the Multiunit Elementary School).

The method of discounting or present value analysis serves to calculate total program cost over several years or over its lifetime regardless of the program's beginning and ending dates. The cost streams of alternative programs are compared as if all costs had been incurred at one point in time to eliminate the factor of dollar value fluctuations. Formulas for estimating the resource impact of investment expenditures and operating costs are provided. Despite its usefulness, discounting does have its limitations. It has been suggested that the potential variability of estimated costs from actual costs be documented.

Determine the Effectiveness of Each Alternative

The appropriateness of measurement scales and gain scores, the identification and management of data which affect student performance, and a delineation of relevant basic descriptive and inferential statistics, are important considerations. All variables affecting student performance, including those which describe the program, were classified according to an accepted standard typology. It is the nature of these factors and of their scale of measurement that determines appropriate statistical procedures.

The use of descriptive statistics and graphs helps to summarize the nature of relevant effectiveness data into statistics which are required for inferential statistical calculations. The employment of inferential statistics allows one to draw conclusions about the impact of various educational treatments. The proper design of an effectiveness evaluation will insure valid data gathering, thereby making possible a judgment about a program's (treatment's) worth. The purpose is to eliminate control or external factors, those which are not solely a part of a program's design, to estimate the impact of a program on the performance of students in accomplishing program objectives.

Test forms are horizontally equated so that the derived normative scores between forms are directly equivalent after they are converted from raw scores or vertically equated to a single scale in order to measure achievement at a higher placement level. Test items can also be tailored in difficulty to each student rather than to each group. Gain scores are obtained from pre- and posttesting during programmatic intervention. Suggestions were made to increase the reliability and validity of such scores. Raw scores often are converted to normative scores to indicate the relative position of the score to a distribution of scores. Several conversion methods are available, each with its advantages and disadvantages. It should be remembered that the time period over which evaluation is conducted can affect the relative effectiveness of educational treatments.

The distribution of gain scores can be examined to see how the treatment impacted on different groups of students. Criterion-referenced gain scores derived from domain-referenced tests suggest the level of functioning if an entire set of items in a cognitive domain were administered.

An important factor in the specification of input-output relationships involves the level at which data are aggregated. This becomes the unit of analysis when statistical procedures are employed.

Because a potentially large number of variables impact on student performance, factor analysis may be employed to organize the variables into manageable groups or clusters. Tradeoffs, however, will be made when such a technique is employed.

A convenient matrix table of statistical procedures can be used to facilitate the selection of the appropriate procedures. The selection is based upon the number of independent, control, and dependent variables involved in the estimation of educational production, measurement scale for each variable, and assumptions about the nature of variable distribution.

Inferential statistical methods can be used to select input variables for entry into an educational production function and multivariate statistical analyses. Those include regression and correlational analyses, one-way analysis of variance, analysis of covariance, several chi-square tests and a variety of other statistics. Several analytical methods may be employed to simultaneously analyze one or more independent variable(s). This seems appropriate to educational evaluation, since there exists a host of variables which appear to impact simultaneously on educational achievement and learning as reviewed in Chapter III. Thus, logical extensions of the univariate techniques mentioned above are multiple regression analysis (several techniques are available), path analysis, canonical correlation, discriminant analysis, analysis of covariance and curvilinear regression. A major concern in multiple regression analysis is recognizing, assessing or limiting the effect of multicollinearity on the variables under study. An assessment should be made of regression data and equations. Such an assessment considers the underlying assumptions of regression, the "goodness" of data, and the regression equation's sufficiency as evaluated by examining unaccounted for variations in the data.

Display the Results from Cost and Effectiveness Determinations Against the Evaluative Criteria

Once cost and effectiveness estimates are made, the findings must be displayed in a manner clearly understandable to the reader. Such a display should be consistent with the breakdown of a program's objectives, activities, and resource requirements. Verbal, tabular, and graphic communications are useful.

State the Non-quantifiable and Uncertainty Factors

A degree of uncertainty will be present in every analysis. Uncertainties should be identified and their impact evaluated. These uncertainties create a possible range of costs and benefits for each alternative which may overlap each alternative at various cost and effectiveness values. Approaches are available which provide for systematic and direct use of expert judgment including group decision-making techniques, and sensitivity, contingency and *a fortiori* analyses.

Merge Cost and Effectiveness Information into a Decision Framework and Document the Merits of Each Alternative

The relationship between cost and effectiveness is never quantitatively clear cut, but tabular displays and analytical models can facilitate an estimation of the relationship. The use of ratios and mathematical models, and productivity analyses have been suggested and utilized to integrate the cost and effectiveness dimensions. Decision criteria were established and documented.

TECHNICAL REPORT NO. 390
(Part 3 of 3 Parts)

an analytical process model for ost-effectiveness/ productivity evaluations of alternative educational programs

JULY 1976

WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

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(Part 3 of 3 Parts)

AN ANALYTICAL PROCESS MODEL FOR COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS OF ALTERNATIVE EDUCATIONAL PROGRAMS

by

Joseph J. Marinelli

Report from the Project on
Organization for Instruction and
Administrative Arrangements

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WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

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The mission of the Wisconsin Research and Development Center for Cognitive Learning is to help learners develop as rapidly and effectively as possible their potential as human beings and as contributing members of society. The R&D Center is striving to fulfill this goal by

- conducting research to discover more about how children learn
- developing improved instructional strategies, processes and materials for school administrators, teachers, and children, and
- offering assistance to educators and citizens which will help transfer the outcomes of research and development into practice

PROGRAM

The activities of the Wisconsin R&D Center are organized around one unifying theme, Individually Guided Education.

FUNDING

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ABSTRACT

AN ANALYTICAL PROCESS MODEL FOR COST-EFFECTIVENESS/PRODUCTIVITY EVALUATIONS OF ALTERNATIVE EDUCATIONAL PROGRAMS

JOSEPH JOHN MARINELLI

Under the Supervision of Professor Richard A. Rossmiller

The purposes of this study were (1) to ascertain the state of the art with regard to cost-effectiveness and productivity analyses in education and (2) to develop an appropriate cost-effectiveness analytical process model for education.

Design of the Study

Specifications for the model required that it be integrated with a conceptual framework of formal education for economic analysis and that it conform to requirements drawn from (1) purposes of the study, (2) systems designs in general, (3) economic and systems theory and analyses, and (4) cost-effectiveness and productivity literature.

For purposes of this study, cost-effectiveness was defined as an economic and systems evaluation technique for comparing the productivity of pre-selected competing alternatives established for accomplishing some desired end, whereby the resource consumption and output, attributable only to each alternative, are integrated into a common decision framework.

Major Findings

Following review of the economic and systems framework within which cost-effectiveness evaluations operate, requirements for the model were stipulated from a discussion of the economic value, quantification, and costing of education, and techniques of economic and systems analysis related to efficiency and productivity. The cost-effectiveness review included a classification of the various applications (models) based upon different views of definition, role, analytical boundaries, research design, and procedures and specification of commonly recognized requirements. The review of productivity in education consisted of identifying and classifying input-output models of educational production, discussing analytical problems, and displaying the results of a number of studies in a manner consistent with the typology of inputs described in the educational system model adopted earlier.

To specify an analytical process model, the nine major generally recognized steps of cost-effectiveness evaluations were examined. This examination revealed the essential process elements and relationships within, boundaries of, and relationships between each step. The review included an examination of classifications of learning and objectives, curriculum descriptors, cost models and analyses, descriptive summary statistics, variables for selection for education production functions, and multivariate inferential statistical procedures. Some prescriptive guidelines and references were also provided for potential users of the model.

The general model and submodels representing each of the nine steps were specified in a network of flow diagrams showing the sequence of analytical operations and cause-effect relationships between process elements. The general model classifies the steps according to the three dimensions: cost, effectiveness/productivity, and integration of these two components. The submodels are:

1. Specify the desired goals and objectives that the alternative educational programs are to fulfill.
2. Distinguish the alternative programs.
3. Specify evaluative criteria (measures) of effectiveness.
4. Specify evaluative criteria (measures) of cost.
5. Determine the cost of each alternative.
6. Determine the effectiveness of each alternative.
7. Display the results from cost and effectiveness determinations against the evaluative criteria.
8. Merge cost and effectiveness information into a decision framework and document the merits of each alternative.
9. State the non-quantifiable and uncertainty factors.

Steps of the general model were integrated with the conceptual framework of an educational system from a viewpoint of economic analysis.

Implications

The prototype model developed in this research needs to be refined through the use of initial case studies and subsequent large scale field tryouts. It should provide practitioners with a methodology which can be employed to evaluate the productivity of Individually Guided Education and other educational programs and to provide feedback from the field

to program designers, implementors, and evaluators. An analytical process model of this type allows for research on direct applications of cost-effectiveness analysis to instructional programs and processes. Thus the systematic consideration of alternatives including new instructional methodologies should be advanced.

Approved by Richard A. Rossmiller
Richard A. Rossmiller

Date May 27, 1976

CHAPTER VI

SPECIFICATION OF THE COST-EFFECTIVENESS/PRODUCTIVITY ANALYTICAL PROCESS MODEL FOR COMPARING EDUCATIONAL PROGRAMS

The model which is specified in this chapter in the form of an analytical process for cost-effectiveness evaluations represents an integration of information obtained from a review of the literature dealing with the major recognized steps of cost-effectiveness reported in Chapter V. The general model which will be presented denotes the steps which comprise the three components of cost-effectiveness; a cost dimension, an effectiveness dimension, and a component which integrates the cost and effectiveness dimensions. The model also identifies the major steps and process elements within those steps. The model's specification also indicates where the overall analytical process integrates with education as a system subject to economic analysis. The network of flow diagrams shows the sequence of analytical operations. The direction of each solid line shows the direction of the perceived relationship or the effects produced by one process element on another. Broken lines indicate a relationship that either affects the submodel of the major step or is effected by the submodel. Diamond-shaped symbols are used to document points in the flowcharts where options exist.

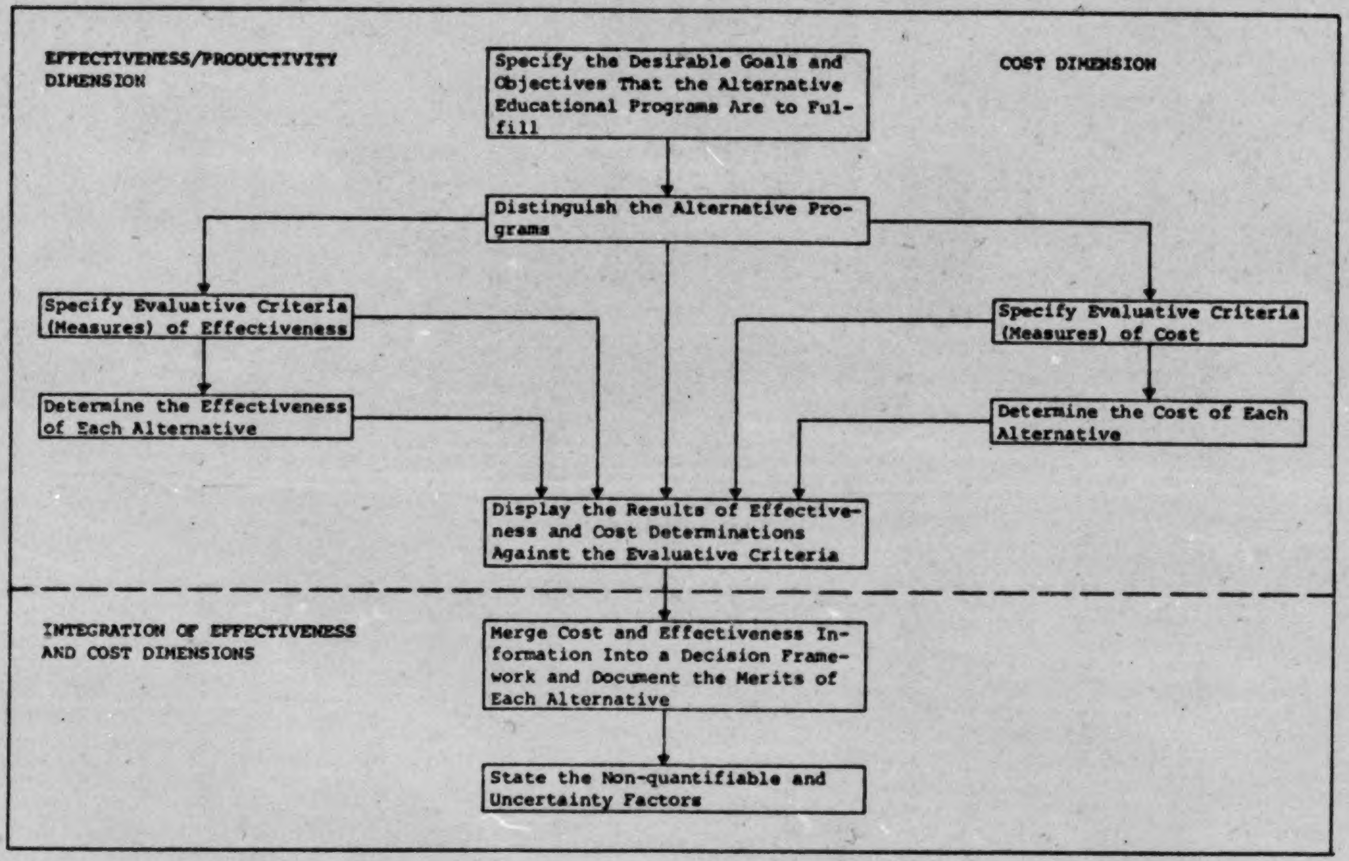
EFFECTIVENESS/PRODUCTIVITY DIMENSION
COST DIMENSION
Specify the Desirable Goals and Objectives That the Alternative Educational Programs Are to Fulfill
Distinguish the Alternative Programs
Specify Evaluative Criteria (Measures) of Effectiveness
Specify Evaluative Criteria (Measures) of Cost
Determine the Effectiveness of Each Alternative
Determine the Cost of Each Alternative
Display the Results of Effectiveness and Cost Determinations Against the Evaluative Criteria
INTEGRATION OF EFFECTIVENESS AND COST DIMENSIONS
Merge Cost and Effectiveness Information Into a Decision Framework and Document the Merits of Each Alternative
State the Non-quantifiable and Uncertainty Factors

Figure 6.1--General Cost-Effectiveness/Productivity Analytical Process Model for Comparing Educational Programs

General Model of Cost-Effectiveness/Productivity

The general model of cost-effectiveness/productivity (Figure 6.1) consists of nine major steps which can be examined from three dimensions; those steps which form the cost dimensions, those steps which are part of the effectiveness/productivity dimension, and those which bring the two dimensions into a decision framework. Steps 1, 2 and 3 are part of both the cost and the effectiveness/productivity dimensions.

A specification of desirable goals and objectives is matched against those of pre-established programs in order to determine which objectives and test items will be included in measures of effectiveness. These two steps are also required to provide a framework in Step 4 for distinguishing the quantity, quality, and combination of resources required of each alternative broken down by program instructional objectives.

Any display of results from analysis must contain both cost and effectiveness data from Steps 5 and 6 matched against their respective criteria from Steps 3 and 4 in such a fashion as to distinguish the alternative programs. A taxonomy is developed in Step 2 to accomplish that purpose.

Cost and effectiveness/productivity dimensions are integrated when information from both is merged into a decision framework, the merits of each alternative are documented and non-quantifiable and uncertainty factors are reported.

Step 1: Specify the Desirable Goals and Objectives that the Alternative Educational Programs Are to Fulfill (Figure 6.2)

Cost-effectiveness analysis as defined for purposes of this study does not involve the determination of desirable program goals and objectives. It does, however, require a specification of those goals and objectives which created a need to ascertain which alternative program is most cost-effective with respect to achieving those goals and objectives. Instructional models for each program alternative will have as their conceptual base a theory of intelligence, personality, and instruction. A delineation of intelligence and personality theories provides a framework for organizing the criterion domain, and instructional theory provides a framework for organizing the treatment domain. It is important that these be documented, since treatments between instructional models differ primarily in degree of emphasis, not in absolute form. The theories form the basis for the classification of a domain of learning experiences (hierarchy) by skills, knowledge and attitudes.

From the conceptual base the desired objectives and competencies can be developed and specified. For purpose of comparison, such objectives and competencies must be specified so as to be measurable, but not in a manner which will create an inappropriate (versus natural) bias in favor of one alternative. For purpose of evaluation, the objectives must specify a criterion level of performance expected of the student, in addition to the activity in which the student engages when he is evaluated (action) and the condition under which the evaluation will take place (context or signal). The criterion level of performance

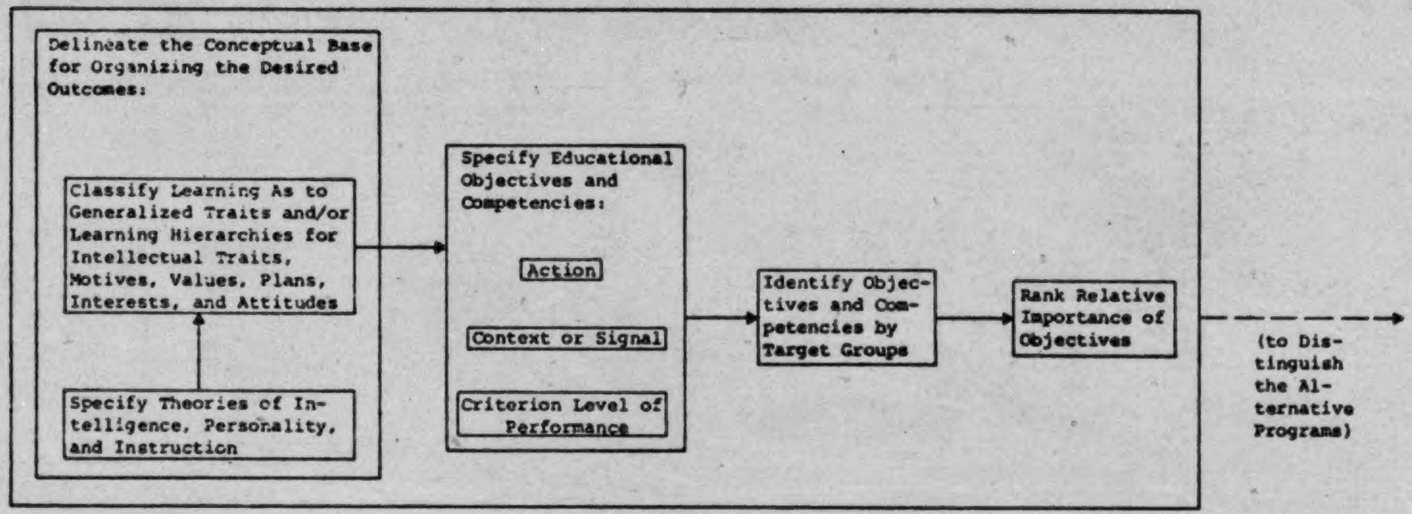
Delineate the Conceptual Base for Organizing the Desired Outcomes:
Classify Learning As to Generalized Traits and/or Learning Hierarchies for Intellectual Traits, Motives, Values, Plans, Interests, and Attitudes
Specify Theories of Intelligence, Personality, and Instruction
Specify Educational Objectives and Competencies:
Action
Context or Signal
Criterion Level of Performance
Identify Objectives and Competencies by Target Groups
Rank Relative Importance of Objectives
(to Distinguish the Alternative Programs)

Figure 6.2—Specify the Desirable Goals and Objectives That the Alternative Educational Programs Are to Fulfill

is the prerequisite for the development, adoption or adaptation of measures of student performance (Step 3).

Each objective, or group of objectives, may be targeted to specific student groups, e.g., gifted, "average," or handicapped children or socioeconomic status groupings. The targeted groups need to be documented, since the evaluator then must consider the impact of each program as it seeks to accomplish objectives for specified target groups.

Since some objectives are likely to be more important than others, a relative ranking must accompany the specification of objectives.

Step 2: Distinguish the Alternative Programs (Figure 6.3)

The more complete the description of each educational program, the more adequate will be the specification of resource requirements. This, in turn, will enhance the quality of the comparative estimates of the alternative programs.

Initially, the content, instructional design, and strategies (curricular process) of each program must be described. An instructional strategy is at the heart of educational programs, and it is the different instructional strategies which subsequently require a different quality, quantity, and combinations of resources. In the case of any program which was not established specifically to meet the goals and objectives specified in Step 1, the conceptual base, goals, objectives, etc., of each must be specified. This enables one to compare each program objective with those of other programs and those established in Step 1.

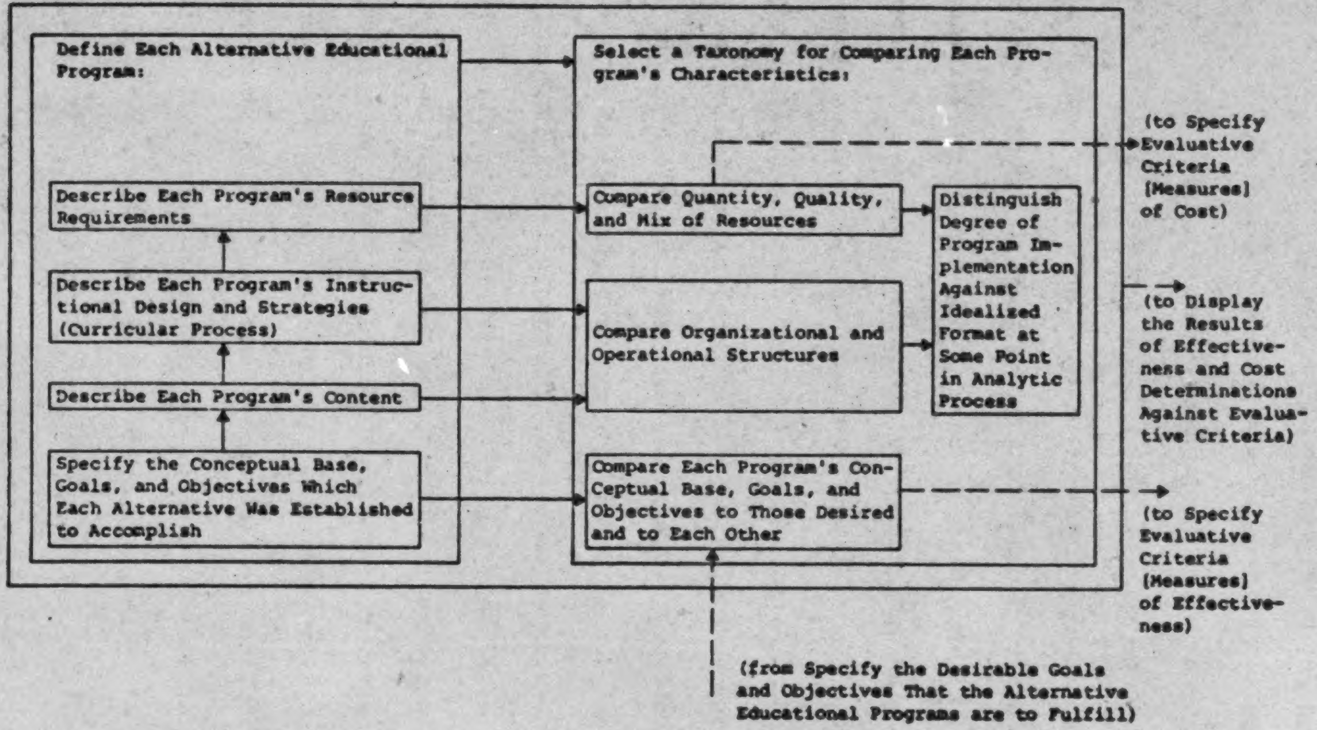
Define Each Alternative Educational Program:
Describe Each Program's Resource Requirements
Describe Each Program's Instructional Design and Strategies (Curricular Process)
Describe Each Program's Content
Specify the Conceptual Base, Goals, and Objectives Which Each Alternative Was Established to Accomplish
Select a Taxonomy for Comparing Each Program's Characteristics:
Compare Quantity, Quality, and Mix of Resources
Compare Organizational and Operational Structures
Compare Each Program's Conceptual Base, Goals, and Objectives to Those Desired and to Each Other
Distinguish Degree of Program Implementation Against Idealized Format at Some Point in Analytic Process
(to Specify Evaluative Criteria [Measures] of Cost)
(to Display the Results of Effectiveness and Cost Determinations Against Evaluative Criteria)
(to Specify Evaluative Criteria [Measures] of Effectiveness)
(from Specify the Desirable Goals and Objectives That the Alternative Educational Programs are to Fulfill)

Figure 6.3--Distinguish the Alternative Programs

Subsequent to the foregoing procedure, a taxonomy must be established so that a set of guidelines is available to facilitate comparisons between programs. The taxonomy must enable the analyst to distinguish between each program's conceptual base, goals and objectives, and its degree of congruence with the goals and objectives specified for analysis in Step 1. Organizational and operational structures must also be compared. The set of dimensions must be flexible enough to allow for the description of any number of novel, innovative or traditional delivery systems and the degree to which they have been implemented. However, the list of dimensions must not be so exhaustive as to be unmanageable. Such a taxonomy must distinguish the quality, quantity, and mix of resources applied in each educational setting. The implemented educational program must be described, for there are different classroom, school, or school district interpretations of an idealized instructional model, and the actual implementation of apparently different curricula may reveal some striking similarities. A taxonomy should include such dimensions as horizontal organization for instruction, group or class size, resource input specifications, instructional support, and auxiliary services. Elements to distinguish classroom activities may include prescriptive practices, testing practices, teacher's reinforcement behavior, instructional materials consumed, and allocation of teacher and student time, among others. Specific schemes are available for examining individualized curricula and for quantifying descriptors of content and instructional processes.

The distinction of the quantity, quality, and mix of resources between programs also provides a framework for distinguishing the quantity, quality, and combination of resources actually consumed in each program, the task which is addressed in Step 4. Likewise, the comparison of program goals and objectives with those desired assists in the specification of effectiveness measures to be operationalized in Step 3.

Step 3: Specify Evaluative Criteria (Measures) of Effectiveness (Figure 6.4)

The analyst is concerned at this step with converting program objectives into one or more measures of student performance. A preliminary step might involve an examination of anthologies of achievement tests and/or attitude scales consistent with program objectives to ascertain whether or not valid and reliable measures of program objectives are available.

Three options are available; one may either adopt, adapt, or develop a measure of student performance. One may choose to select a test from an existing test battery or from one which has been specially constructed to measure a single subject area. Program evaluators also may choose to develop a unique measure specifically to evaluate the programs under study. When this is not possible due to insufficient resources and/or time, then a measure which offers the best fit between test items and the objectives of all programs may be selected.

If the purpose, based upon the program objectives, is to measure proficiency, mastery, and understanding of general and specific areas of knowledge, then achievement tests are appropriate. However, if the purpose is to assess a predisposition towards a referent or cognitive object as observed through expressed throughts, feelings, perceptions

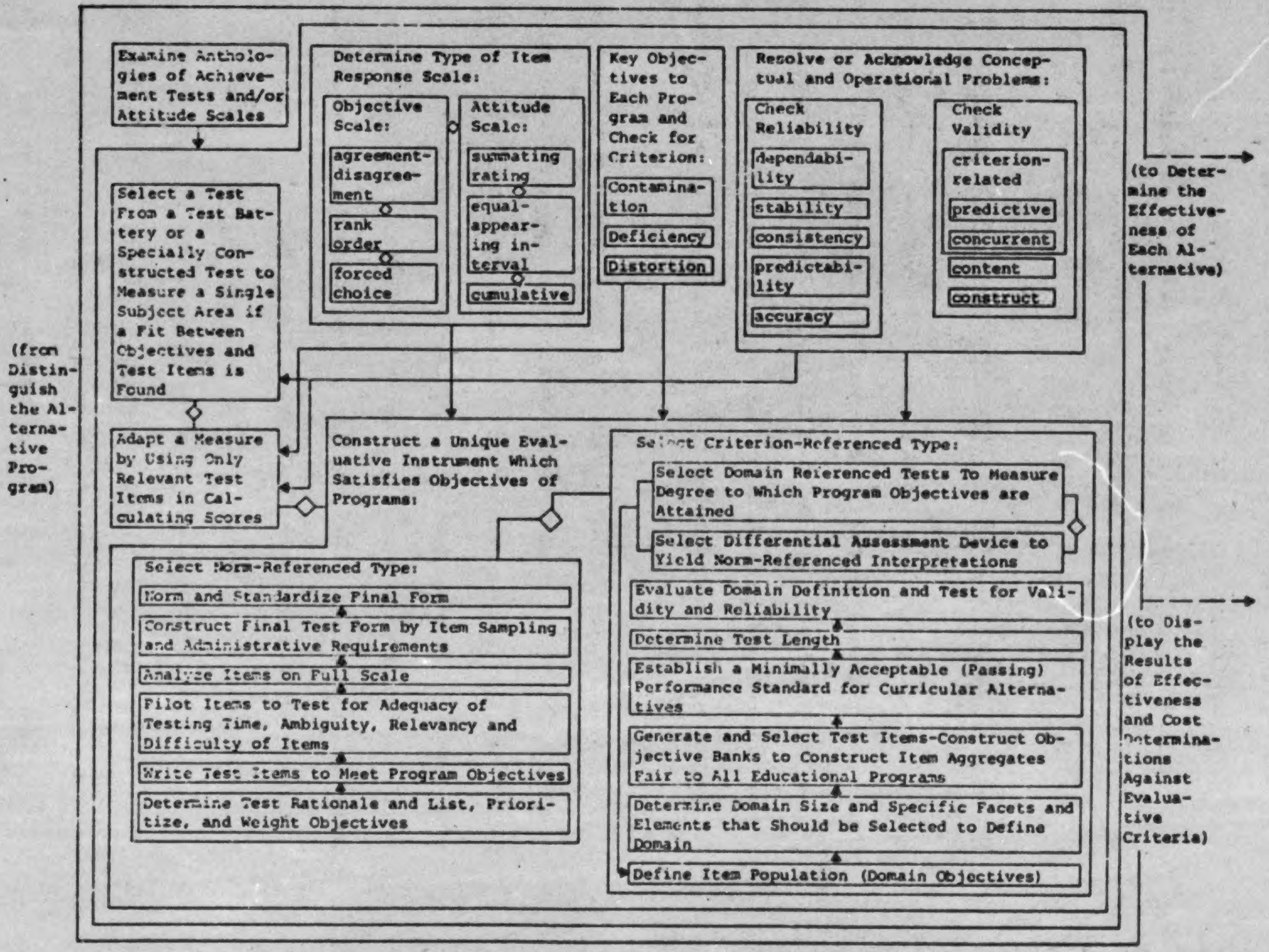
Examine Anthologies of Achievement Tests and/or Attitude Scales
Determine Type of Item Response Scale:
Objective Scale:
agreement-disagreement
rank order
forced choice
Attitude Scale:
summating rating
equal-appearing interval
cumulative
Key Objectives to Each Program and Check for Criterion:
Contamination
Deficiency
Distortion
Resolve or Acknowledge Conceptual and Operational Problems:
Check Reliability
dependability
stability
consistency
predictability
accuracy
Check Validity
criterion-related
predictive
concurrent
content
construct
(to Determine the Effectiveness of Each Alternative)
Select a Test From a Test Battery or a Specially Constructed Test to Measure a Single Subject Area if a Fit Between Objectives and Test Items is Found
(from Distinguish the Alternative Program)
Adapt a Measure by Using Only Relevant Test Items in Calculating Scores
Construct a Unique Evaluative Instrument Which Satisfies Objectives of Programs:
Select Criterion-Referenced Type:
Select Domain Referenced Tests To Measure Degree to Which Program Objectives are Attained
Select Differential Assessment Device to Yield Norm-Referenced Interpretations
Evaluate Domain Definition and Test for Validity and Reliability
Determine Test Length
Establish a Minimally Acceptable (Passing) Performance Standard for Curricular Alternatives
Generate and Select Test Items-Construct Objective Banks to Construct Item Aggregates Fair to All Educational Programs
Determine Domain Size and Specific Facets and Elements that Should be Selected to Define Domain
Define Item Population (Domain Objectives)
Select Norm-Referenced Type:
Norm and Standardize Final Form
Construct Final Test Form by Item Sampling and Administrative Requirements
Analyze Items on Full Scale
Pilot Items to Test for Adequacy of Testing Time, Ambiguity, Relevancy and Difficulty of Items
Write Test Items to Meet Program Objectives
Determine Test Rationale and List, Prioritize, and Weight Objectives
(to Display the Results of Effectiveness and Cost Determinations Against Evaluative Criteria)

Figure 6.4--Specify Evaluative Criteria (Measures) of Effectiveness

and behaviors, then attitude scales are appropriate. Cognitive achievement is also a function of noncognitive factors. If such noncognitive factors are not identified, then the amount of information which will be available to evaluators will be reduced.

When a decision is made to construct a unique evaluative instrument, a norm-referenced (locally normed) or criterion-referenced measuring instrument may be chosen. Six steps are involved in constructing a norm-referenced test:

1. Determine test rationale and objectives; list, prioritize, and assign weights to them.
2. Write test items to meet specified objectives.
3. Pilot test the items for adequacy of testing time, ambiguity, relevancy, and difficulty of items.
4. Analyze the items on full scale.
5. Construct a final test form which comprises item sampling and administrative requirements.
6. Norm and standardize the final form.

Whereas norm-referenced measures compare a student or group's performance relative to another previously tested population of students, criterion-referenced measures produce scores related to tasks or performance on specific student knowledge and skills acquisition. The procedure for conducting these steps is as follows:

1. Define the domain objectives (from analytical Steps 1 and 2).
2. Determine the size of the domain and specific facets and elements that should be selected to define the domain.
3. Develop a pool of objectives to construct criterion-referenced aggregates fair to two or more curricula.

4. Generate and select test items.

5. Establish a minimally acceptable (passing) performance standard for the curricular alternatives.

6. Determine test length.

7. Evaluate the domain definition and test for validity and reliability.

Two types of criterion-referenced measures are available: domain-referenced tests or differential assessment devices. Differential assessment devices reveal student and group differences, but do not measure the level of functioning because only items which discriminate between students are selected. Domain-referenced tests, on the other hand, examine the degree of objective attainment.

Related to the development of an achievement test or attitude scale is the need for a decision with respect to the type of required examinee response. Agreement-disagreement, rank order, and forced choice are available for such achievement test purposes, as are summated rating, equal-appearing interval, and cumulative response formats for attitude scales.

Issues of reliability and validity must be resolved in constructing a test instrument and/or in using a single test instrument for measuring student progress in more than one program. This information is published for the prospective users of commercial test batteries or specially constructed tests. Checks must be made to insure that measurement devices are dependable, stable, consistent, predictable and accurate. Measures must also be valid. Content validity is concerned with the representativeness (sampling adequacy) of test items to domain objectives. Concurrent and predictive validity are criterion-related measures; that is, the extent to which the instrument can predict to an outside criterion and against a measuring instrument for the present (concurrent) or in the future (predictive). Judgments about a measure's strength in assessing underlying properties of test items is termed construct validity.

Since standardized tests are unlikely to measure all objectives included in each program, test items should be keyed to each program's objectives to identify or determine criterion contamination (elements extraneous to a given curriculum), criterion distortion (greater weighting given to a particular curriculum's content), and criterion deficiency (omission of pertinent content). A single measurement instrument should be equally valid for each program alternative.

Step 4: Specify Evaluative Criteria (Measures) of Cost (Figure 6.5)

The initial step in specifying an evaluative criterion (measure) of cost is to specify the concept of cost which will serve as the framework for the development of a cost model. Two options generally are available; the emerging opportunity cost concept or the traditional program expenditure concept. The program expenditure concept is concerned with tracking monetary outlays; the opportunity cost concept views costs as the benefits given up as a result of choosing to utilize resources in one manner rather than in another manner. The uses made of staff and student time, for example, are important considerations in the opportunity cost approach.

Another precondition to the development of a cost element structure is a statement of the model's desired (1) degree of complexity,

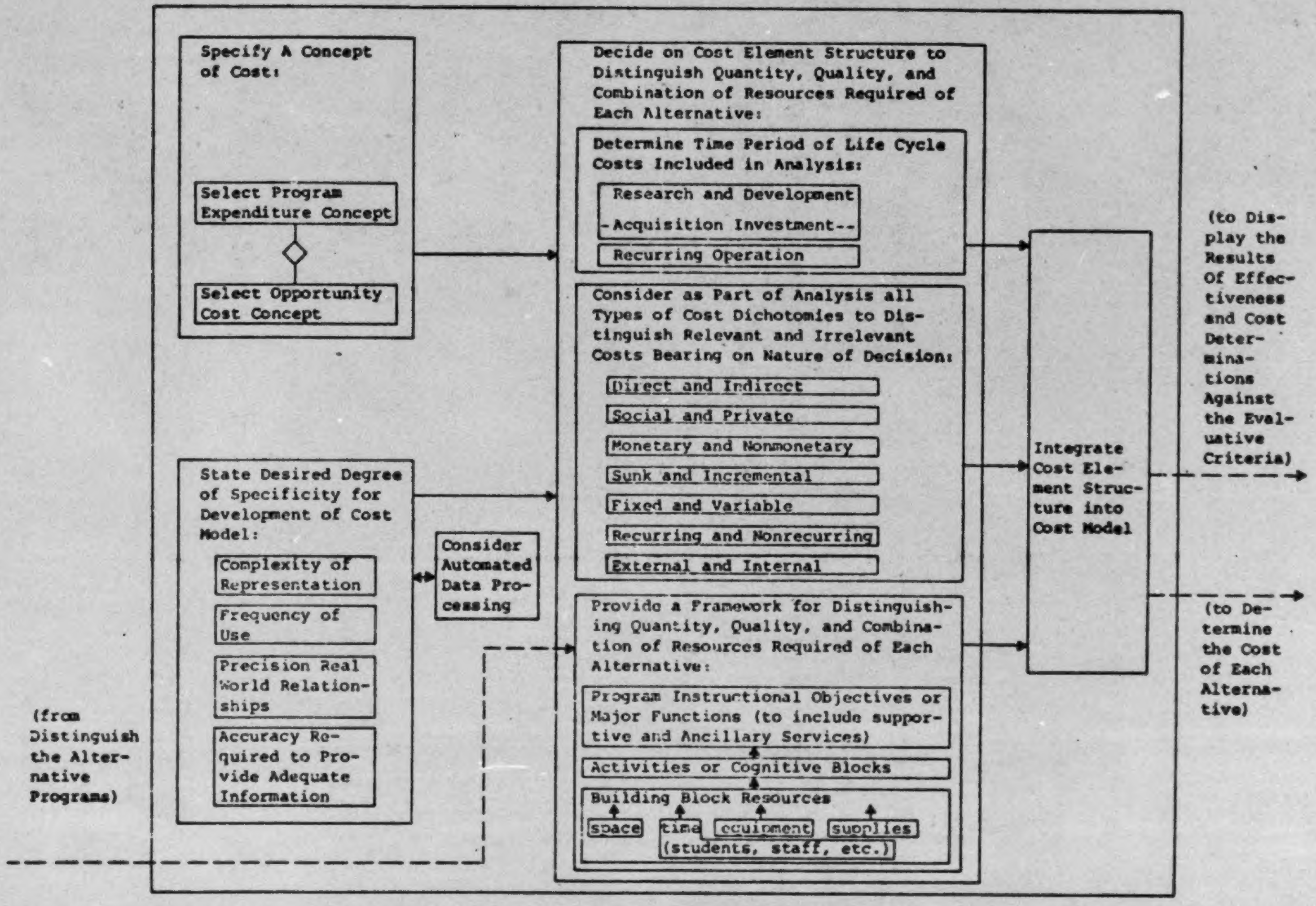
Specify A Concept of Cost:
Select Program Expenditure Concept
Select Opportunity Cost Concept
State Desired Degree of Specificity for Development of Cost Model:
Complexity of Representation
Frequency of Use
Precision Real World Relationships
Accuracy Required to Provide Adequate Information
Consider Automated Data Processing
(from Distinguish the Alternative Programs)
Decide on Cost Element Structure to Distinguish Quantity, Quality, and Combination of Resources Required of Each Alternative:
Determine Time Period of Life Cycle Costs Included in Analysis:
Research and Development
Acquisition Investment
Recurring Operation
Consider as Part of Analysis all Types of Cost Dichotomies to Distinguish Relevant and Irrelevant Costs Bearing on Nature of Decision:
Direct and Indirect
Social and Private
Monetary and Nonmonetary
Sunk and Incremental
Fixed and Variable
Recurring and Nonrecurring
External and Internal
Provide a Framework for Distinguishing Quantity, Quality, and Combination of Resources Required of Each Alternative:
Program Instructional Objectives or Major Functions (to include supportive and Ancillary Services)
Activities or Cognitive Blocks
Building Block Resources
space
time
equipment
supplies
(students, staff, etc.)
Integrate Cost Element Structure into Cost Model
(to Display the Results Of Effectiveness and Cost Determinations Against the Evaluative Criteria)
(to Determine the Cost of Each Alternative)

Figure 6.5--Specify Evaluative Criteria (Measures) of Cost

(2) precision with regard to actual relationships, (3) accuracy, and (4) estimated frequency of use. The above considerations are important, for a cost model must balance the need for sensitivity to cost variations (criterion differences) between alternatives with the need for manageability in order to make the model time-responsive. At this point one should determine the need for an automated data processing system.

The specification of the ideal cost element structure includes three dimensions:

1. A framework for distinguishing the quantity, quality and combination of resources required of each alternative;
2. The period of time of a program's life cycle during which costs will be estimated; and
3. The cost dichotomies which bear on decisions as to which costs are relevant and irrelevant.

The first activity here is the development of a framework for distinguishing the quantity, quality, and combination of resources required of each alternative program. Three prior activities are essential for the completion of this task:

1. Specification of the concept of cost (Step 4);
2. Statement of the desired degree of specificity (Step 4); and
3. Identification of the common set of taxonomic dimensions for comparing program characteristics, i.e., for differentiating the quantity, quality, and mix of resources by objectives and activities (Step 2).

The framework will include a hierarchical arrangement consisting of specific resources such as space, time, equipment and supplies (that is, "building block resources") within each activity or cognitive block within each program objective or major function (See Figure 6.6). Resources

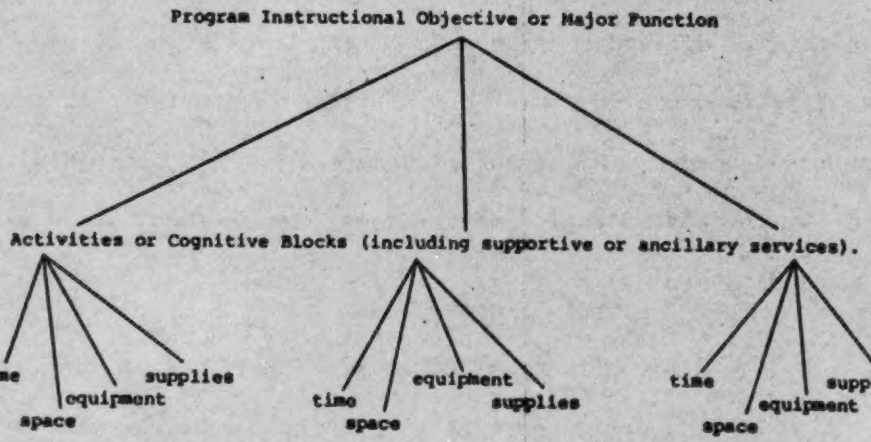
Program Instructional Objective or Major Function
Activities or Cognitive Blocks (including supportive or ancillary services).
time
space
equipment
supplies
time
space
equipment
supplies
time
space
equipment
supplies

Figure 6.6--Framework for Distinguishing the Combination of Resources Required of Program Alternatives

consumed under ancillary or supportive services are assigned or allocated (e.g., prorated) to the activities conducted to achieve each program objective. Where this is not reasonable, they are assigned or prorated to separate functional categories.

The second dimension of a cost element structure is the specification of all cost dichotomies for the purpose of distinguishing relevant from irrelevant costs. Those cost dichotomies as noted in Chapter 5, include:

1. Direct and indirect costs
2. Social and private costs
3. Monetary and nonmonetary costs
4. Sunk and incremental costs
5. Fixed and variable costs
6. Recurring and nonrecurring costs
7. External and internal costs.

The third dimension relates to the life-cycle and time period over which program costs will be estimated. Will the cost analysis include program research and development activities, investment activities, operating activities, all life-cycle activities, or a combination of the above? Research, development, and investment activities may be grouped and labelled "acquisition costs." Research and development costs will be those resources required to develop a program alternative to the point at which it can be implemented.

Those costs which are necessary to implement the program are termed investments. Operating costs are those which recur as the program is conducted over time.

With the elements specified, a three dimensional cost model may be illustrated (see Figure 6.7). In those instances where activities cannot reasonably be assigned to program instructional objectives (as may be the case with some research and development activities), these activities may be grouped into major functions.

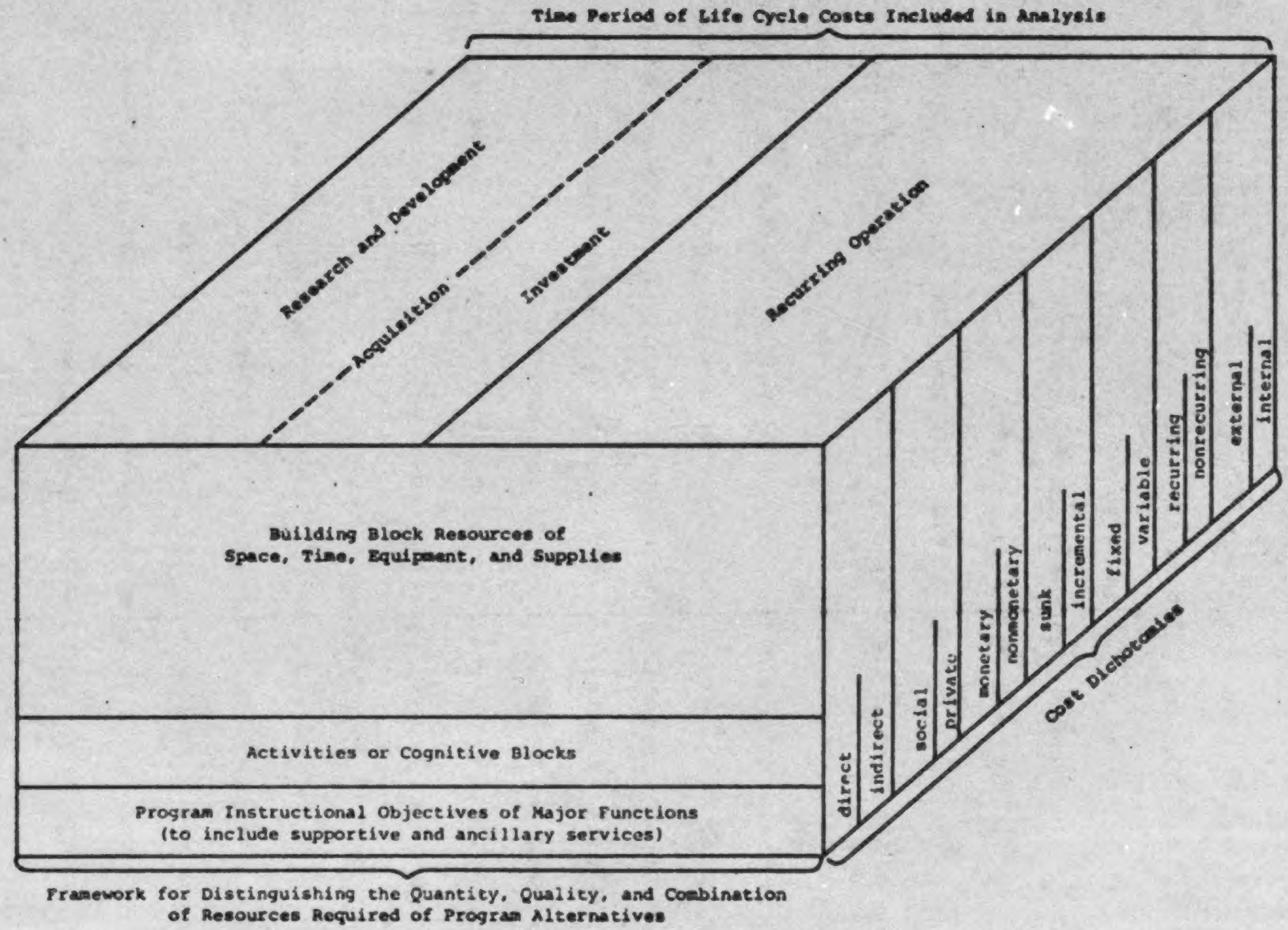
Time Period of Life Cycle Costs Included in Analysis
Research and Development
Acquisition
Investment
Recurring Operation
Building Block Resources of
Space, Time, Equipment, and Supplies
Activities or Cognitive Blocks
Program Instructional Objectives of Major Functions
(to include supportive and ancillary services)
direct
indirect
social
private
monetary
nonmonetary
sunk
incremental
fixed
variable
recurring
nonrecurring
external
internal
Cost Dichotomies
Framework for Distinguishing the Quantity, Quality, and Combination
of Resources Required of Program Alternatives

Figure 6.7--Three Dimensional Program Cost Model

435

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Step 5: Determine the Cost of Each Alternative (Figure 6.8)

Consistent with and subsequent to the development of a framework for distinguishing the quantity, quality, and mix of required resources between the alternative programs is the need for a description of the unique manner in which each type of resources is consumed. The description is a necessary data requirement so as to be able to establish a basis for determining the unit cost of each type of resource. To calculate staff costs, data will be needed on the number of each type of instructional and support staff position (including administration), time spent on each objective activity, and salaries. As salary schedules are used to project future costs, the movement of staff members through the program's activities must be considered. Fringe benefits comprise part of total outlay and thus are included. When a staff member is assigned to one program or activity within a program at the expense of another, then this decision should be documented, since these are foregone opportunity costs. Student personnel costs are measured by "time." In the upper grades student time could be transformed into costs by estimating the foregone earnings of students. In the lower grades, however, time generally is measured in student instructional hours obligated by program, objectives, and activities to achieve those objectives during and outside of school hours. Foregone learning, i.e., the limited or nonparticipation of a student in one program due to participation in another, should be described when not quantifiable. When estimating the cost of facilities, the intensity of space utilization is an important factor. This can be ascertained by recording the amount of time the facility is used and how many students use it, thus

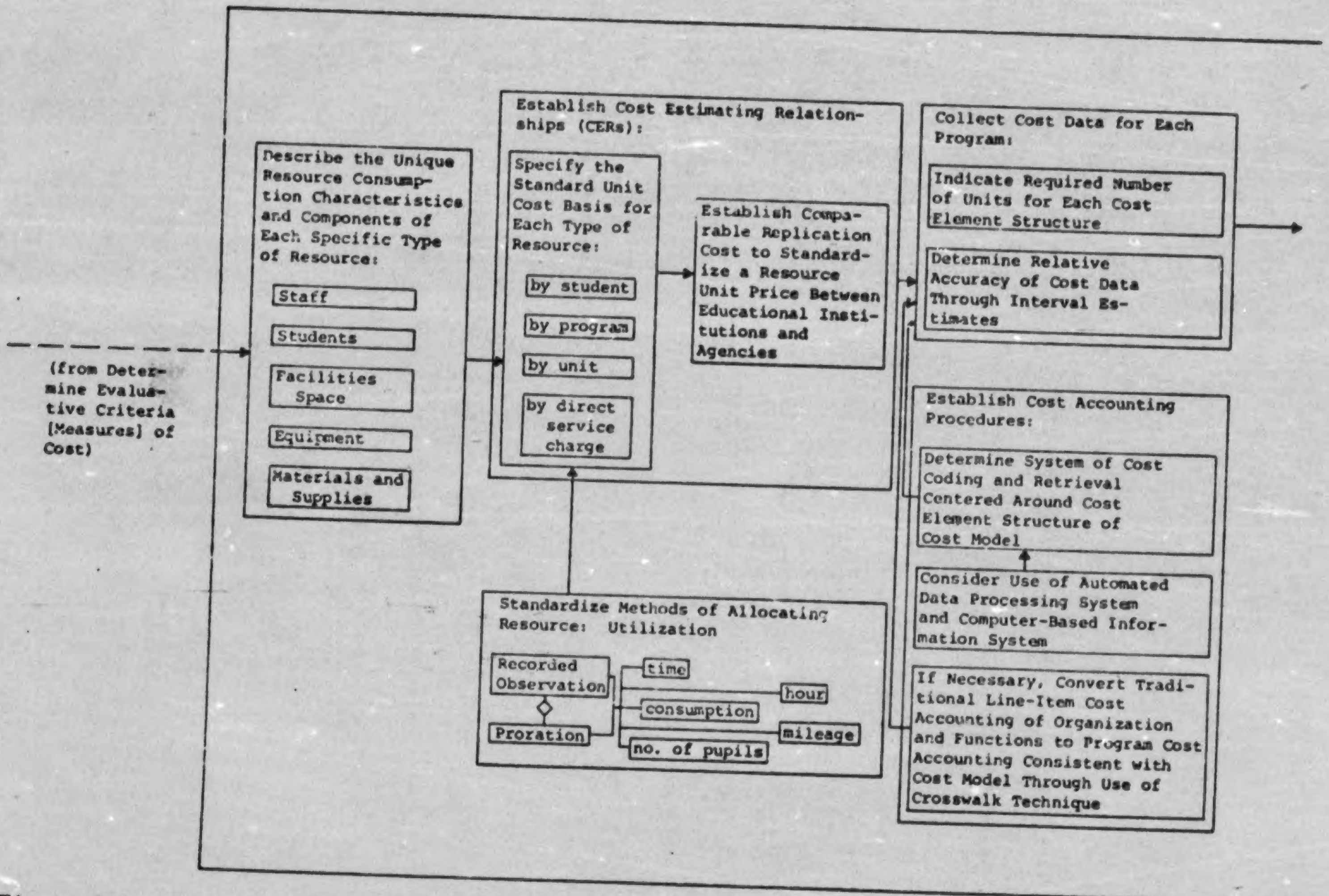

(from Determine Evaluative Criteria [Measures] of Cost)
Describe the Unique Resource Consumption Characteristics and Components of Each Specific Type of Resource:
Staff
Students
Facilities Space
Equipment
Materials and Supplies
Establish Cost Estimating Relationships (CERs):
Specify the Standard Unit Cost Basis for Each Type of Resource:
by student
by program
by unit
by direct service charge
Establish Comparable Replication Cost to Standardize a Resource Unit Price Between Educational Institutions and Agencies
Standardize Methods of Allocating Resource: Utilization
Recorded Observation
Proration
time
hour
consumption
mileage
no. of pupils
Collect Cost Data for Each Program:
Indicate Required Number of Units for Each Cost Element Structure
Determine Relative Accuracy of Cost Data Through Interval Estimates
Establish Cost Accounting Procedures:
Determine System of Cost Coding and Retrieval Centered Around Cost Element Structure of Cost Model
Consider Use of Automated Data Processing System and Computer-Based Information System
If Necessary, Convert Traditional Line-Item Cost Accounting of Organization and Functions to Program Cost Accounting Consistent with Cost Model Through Use of Crosswalk Technique

Figure 6.8--Determine the Cost of Each Alternative

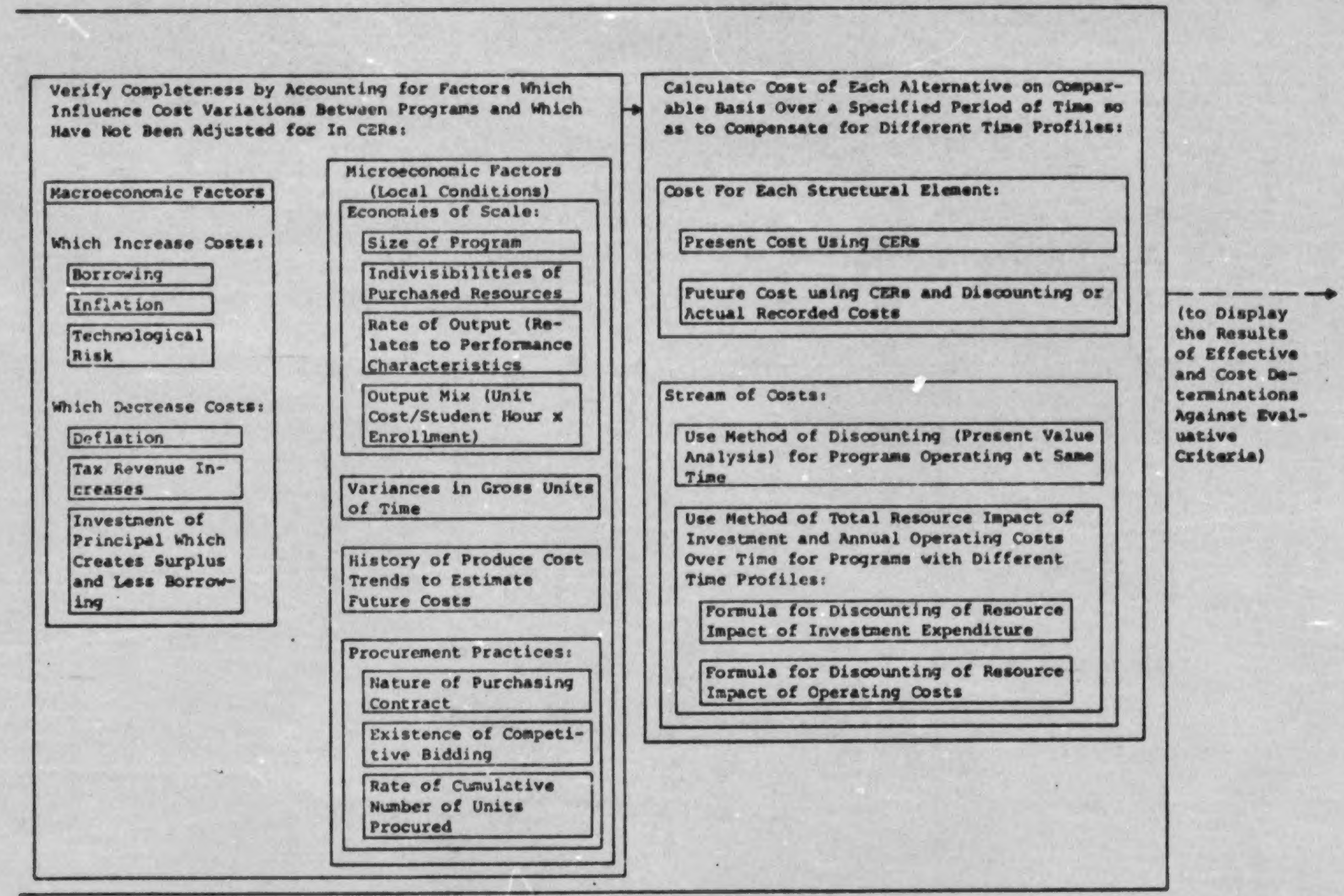

Verify Completeness by Accounting for Factors Which Influence Cost Variations Between Programs and Which Have Not Been Adjusted for In CERs:
Macroeconomic Factors
Which Increase Costs:
Borrowing
Inflation
Technological Risk
Which Decrease Costs:
Deflation
Tax Revenue Increases
Investment of Principal Which Creates Surplus and Less Borrowing
Microeconomic Factors (Local Conditions)
Economies of Scale:
Size of Program
Indivisibilities of Purchased Resources
Rate of Output (Relates to Performance Characteristics
Output Mix (Unit Cost/Student Hour x Enrollment)
Variances in Gross Units of Time
History of Produce Cost Trends to Estimate Future Costs
Procurement Practices:
Nature of Purchasing Contract
Existence of Competitive Bidding
Rate of Cumulative Number of Units Procured
Calculate Cost of Each Alternative on Comparable Basis Over a Specified Period of Time so as to Compensate for Different Time Profiles:
Cost For Each Structural Element:
Present Cost Using CERs
Future Cost using CERs and Discounting or Actual Recorded Costs
Stream of Costs:
Use Method of Discounting (Present Value Analysis) for Programs Operating at Same Time
Use Method of Total Resource Impact of Investment and Annual Operating Costs Over Time for Programs with Different Time Profiles:
Formula for Discounting of Resource Impact of Investment Expenditure
Formula for Discounting of Resource Impact of Operating Costs
(to Display the Results of Effective and Cost Determinations Against Evaluative Criteria)

Figure 6.8--Determine the Cost of Each Alternative yielding a cost per student-hour. Cost components of this resource include (1) interest on debentures (unpaid debt); (2) inputed (foregone) interest on equity; (3) depreciation (annual decrease in value); and (4) overhead for light, power, and heat. Components of equipment cost include imputed interest, maintenance, and depreciation. Consumption of materials and supplies may be estimated by dividing the total annual expenditure for these items by the number of students using them. Better yet, the annual cost estimate should include the number of purchased units, the price per unit, and the life span of purchased units.

To compare costs between programs, a standard unit cost measure must be adopted for each input. The standard unit of measure may be by student; program; direct services performed on one program only; or unit of physical proximity, such as classrooms, resource centers, laboratories, teachers, etc. A combination of units may be applicable for each input category.

In cases where expenditures can be assigned to more than one cost category, two methods of allocation should be utilized--observation or proration. Such factors as time, hours, consumption, mileage, or number of pupils may apply. The actual utilization of resources by recorded observation is undoubtedly the most accurate, but at the same time may be impractical, for the cost of this type of cost accounting activity may be very great.

Where program comparisons cross district lines such that the market from which resources are purchased is different, a standard price per unit of all consumed resources must be set. If this is not done, differences in unit prices will contaminate the comparisons.

Costs based upon a standard price per unit are comparable because the price per unit of resource is adjusted to a comparable replication cost.

The specification of a standard unit cost for each type of resource and of a comparable relication cost comprise the cost estimating relationship. The collection of cost data for each program is a process that employs the cost estimating relationship and indicates the required number of units for each cost element category. In instances where the cost estimates are approximations of the actual cost, it is suggested that an interval estimate of the accuracy of the data accompany the cost estimate, for example, $125.00 ± $5.00, be included. These internal estimates provide an indicator of the relative accuracy of the cost data for each alternative program.

A determining factor of the relative accuracy of cost data will be the manner in which costs are recorded and retrieved which, in turn, is dependent upon methods employed to allocate resource utilization. A system of coding must center around the element structure of the cost model developed in Step 4.

When cost models are large and complex due to a desire for complexity, precision, accuracy and frequent use (Step 4), and consequently a system of coding for time-consuming calculations is required, the use of an automated data processing system is clearly indicated. Although computer-based information systems can assist in the quick retrieval of data and in complex calculations, there always will remain aspects of cost accounting which require the exercise of human discretion.

In comparing program costs, it may be necessary to convert from the traditional line-item format of cost accounting to cost accounting by program, objectives, functions, activities or cognitive blocks consistent with a three dimensional cost model. A "crosswalk" is the expression of a relationship between the two types of costing procedures. The determination of a system of coding, a consideration of automated data processing systems or computer-based information systems, and, if necessary, a "crosswalk" format, constitute the elements of a system of cost accounting essential for the collection of cost data.

Factors exist which influence cost variations between programs and which may not have been accounted for in the cost estimating relationships. After the data are collected for each program, the completeness of the data should be verified by accounting for macroeconomic and microeconomic factors. It is important to examine costs at the time they occur, for there may be a cost advantage based upon the present value of future dollars. Thus, the chronology of expenditures is an important consideration. Several macroeconomic conditions operate to increase costs. Among them are borrowing, inflation, and technological risk (at a time when programs require additional development). Deflation and tax revenue increases stir monetary growth, which raises the value of the expenditure dollar, and the investment of principal, which either produces surplus or less need for borrowing.

Microeconomic (local) factors also operate to cause cost variations. Many of these factors are related to economies of scale, such as size of program and indivisibilities of purchased resources and number of students; rate of units of output, that is, students completing the program (relates to program performance characteristics), and output mix (e.g., unit cost/student hour x enrollment). When gross units of time such as the school day vary between programs, variations in cost will occur. The use of minutes or hours as units of time will neutralize this negative influence on desired comparability. Procurement practices can be examined to ascertain the nature of the purchasing contract, the existence of competitive bidding, and the rate of cumulative number of resource input units procured (volume). The history of product cost trends can lend insight into estimating future costs.

In addition to collecting data for each cost element, one must calculate future total program costs and total program cost streams for a specified time period. The future cost of a specific resource may be estimated by discounting, i.e., multiplying the present cost per unit by $(1+i)^t$, where i=percentage rate of cost increase and t=number of years of projection (current year=0). Total unit costs are equal to the future cost/unit multiplied by the number of required units. The number of future required units may be estimated by the statistical method of least squares, where an association exists (past record or legal requirement) between the required units of two resources.

Just as present value analysis (discounting) was used to approximate the future cost of a specific resource, it applies as well for calculating the total program costs over several years, or over the program's life time regardless of its time profile, i.e., its beginning and end dates. Through discounting, cost streams of alternatives are compared as if all costs had been incurred at one point in time. This effectively neutralizes macroeconomic factors. The collection of data discussed earlier should yield initial research, development, and investment costs and the current annual operating cost for each program.

In addition, an assumed rate of interest and the length of the time over which the programs are to be compared are needed for projecting future and total costs. Using a standard compound interest formula

$X_0 = \frac{X_t}{(1+i)^t}$, where X_t, the future value at time t of X_0, equals $X_0(1+i)^t$, and i=rate of interest, the present value of a stream of costs, $V_0(X)$, equals

$$\frac{X_1}{1+i} + \frac{X_2}{(1+i)^2} + \frac{X_n}{(1+i)^n} \text{ or } \sum_{t=1}^{t=n} \frac{X_t}{(1+i)^n}$$

When the costs of an ongoing educational program are compared to the costs of a new program, the mathematical formulation is different. Two formulas are required--one for calculating the resource impact of investment expenditures and one for calculating the resource impact of operating costs, as discussed in Chapter 5.

Step 6: Determine the Effectiveness of Each Alternative (Figure 6.9)

The initial consideration in determining the effectiveness of each alternative is to establish conditions for evaluation under which some reasonable conclusion can be made about the nature and extent of the relationship between group performance on output measures and all educational programs. Those conditions must be checked against the need for valid data gathering, eliminating or controlling other than program factors which impact upon student performance, and reducing the threat to internal validity. Internal validity is threatened by:

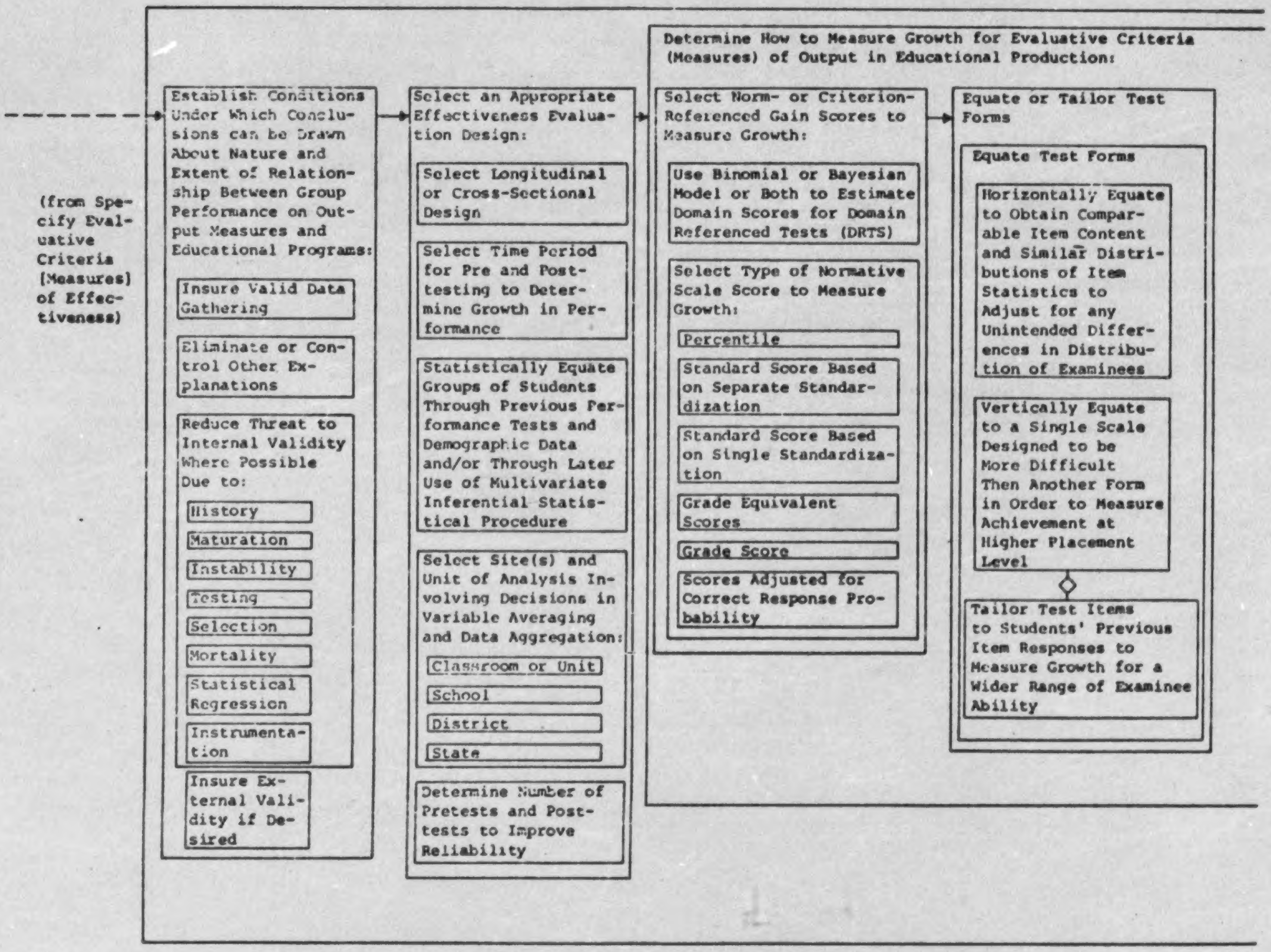
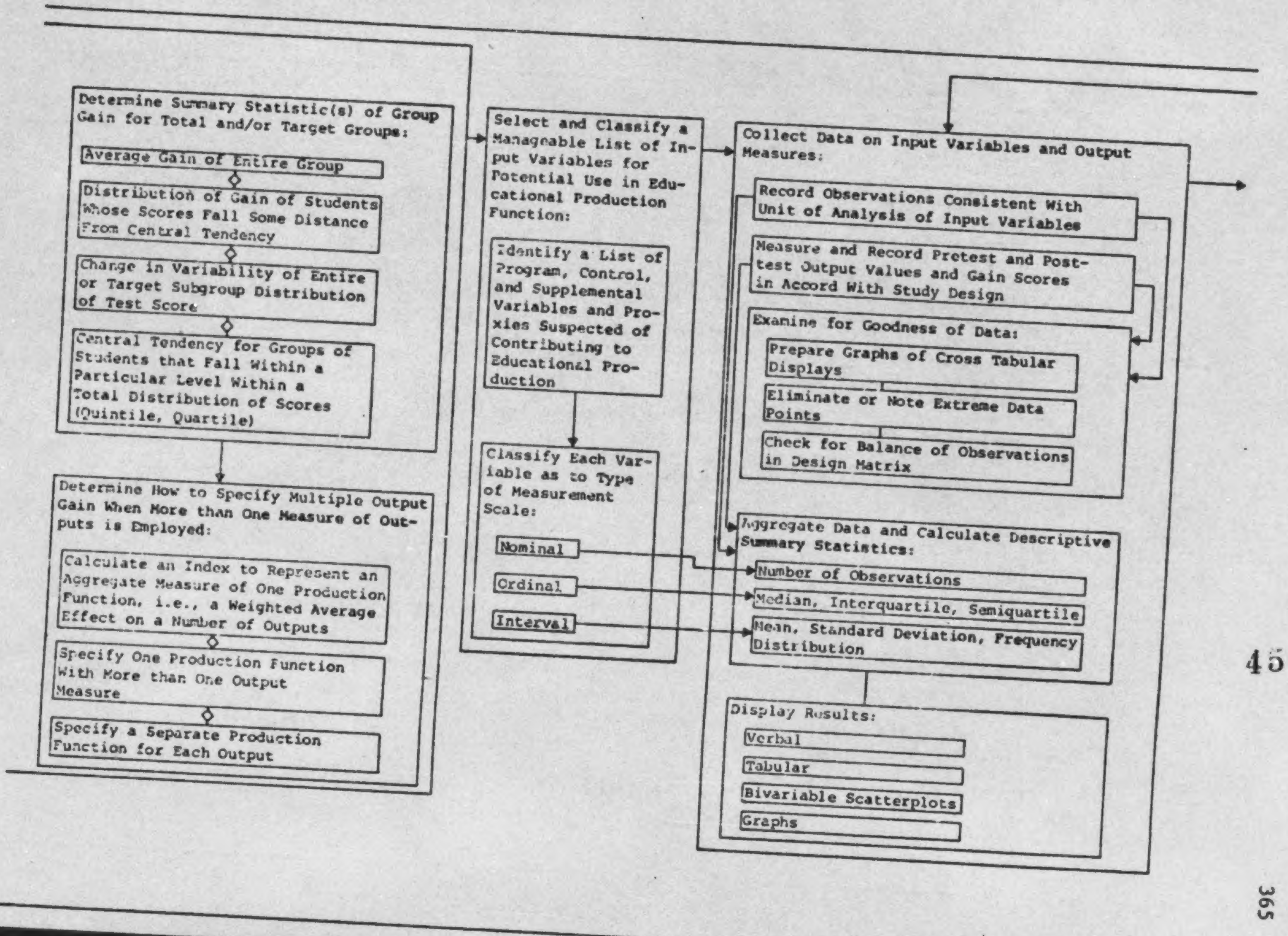

(from Specify Evaluative Criteria [Measures] of Effectiveness)
Establish Conditions Under Which Conclusions can be Drawn About Nature and Extent of Relationship Between Group Performance on Output Measures and Educational Programs:
Insure Valid Data Gathering
Eliminate or Control Other Explanations
Reduce Threat to Internal Validity Where Possible Due to:
History
Maturation
Instability
Testing
Selection
Mortality
Statistical Regression
Instrumentation
Insure External Validity if Desired
Select an Appropriate Effectiveness Evaluation Design:
Select Longitudinal or Cross-Sectional Design
Select Time Period for Pre and Posttesting to Determine Growth in Performance
Statistically Equate Groups of Students Through Previous Performance Tests and Demographic Data and/or Through Later Use of Multivariate Inferential Statistical Procedure
Select Site(s) and Unit of Analysis Involving Decisions in Variable Averaging and Data Aggregation:
Classroom or Unit
School
District
State
Determine Number of Pretests and Posttests to Improve Reliability
Determine How to Measure Growth for Evaluative Criteria (Measures) of Output in Educational Production:
Select Norm- or Criterion-Referenced Gain Scores to Measure Growth:
Use Binomial or Bayesian Model or Both to Estimate Domain Scores for Domain Referenced Tests (DRTS)
Select Type of Normative Scale Score to Measure Growth:
Percentile
Standard Score Based on Separate Standardization
Standard Score Based on Single Standardization
Grade Equivalent Scores
Grade Score
Scores Adjusted for Correct Response Probability
Equate or Tailor Test Forms
Equate Test Forms
Horizontally Equate to Obtain Comparable Item Content and Similar Distributions of Item Statistics to Adjust for any Unintended Differences in Distribution of Examinees
Vertically Equate to a Single Scale Designed to be More Difficult Then Another Form in Order to Measure Achievement at Higher Placement Level
Tailor Test Items to Students' Previous Item Responses to Measure Growth for a Wider Range of Examinee Ability

Figure 6.9--Determine the Effectiveness of Each Alternative


Determine Summary Statistic(s) of Group Gain for Total and/or Target Groups:
Average Gain of Entire Group
Distribution of Gain of Students Whose Scores Fall Some Distance From Central Tendency
Change in Variability of Entire or Target Subgroup Distribution of Test Score
Central Tendency for Groups of Students that Fall Within a Particular Level Within a Total Distribution of Scores (Quintile, Quartile)
Determine How to Specify Multiple Output Gain When More than One Measure of Outputs is Employed:
Calculate an Index to Represent an Aggregate Measure of One Production Function, i.e., a Weighted Average Effect on a Number of Outputs
Specify One Production Function With More than One Output Measure
Specify a Separate Production Function for Each Output
Select and Classify a Manageable List of Input Variables for Potential Use in Educational Production Function:
Identify a List of Program, Control, and Supplemental Variables and Proxies Suspected of Contributing to Educational Production
Classify Each Variable as to Type of Measurement Scale:
Nominal
Ordinal
Interval
Collect Data on Input Variables and Output Measures:
Record Observations Consistent With Unit of Analysis of Input Variables
Measure and Record Pretest and Posttest Output Values and Gain Scores in Accord With Study Design
Examine for Goodness of Data:
Prepare Graphs of Cross Tabular Displays
Eliminate or Note Extreme Data Points
Check for Balance of Observations in Design Matrix
Aggregate Data and Calculate Descriptive Summary Statistics:
Number of Observations
Median, Interquartile, Semiquartile
Mean, Standard Deviation, Frequency Distribution
Display Results:
Verbal
Tabular
Bivariable Scatterplots
Graphs

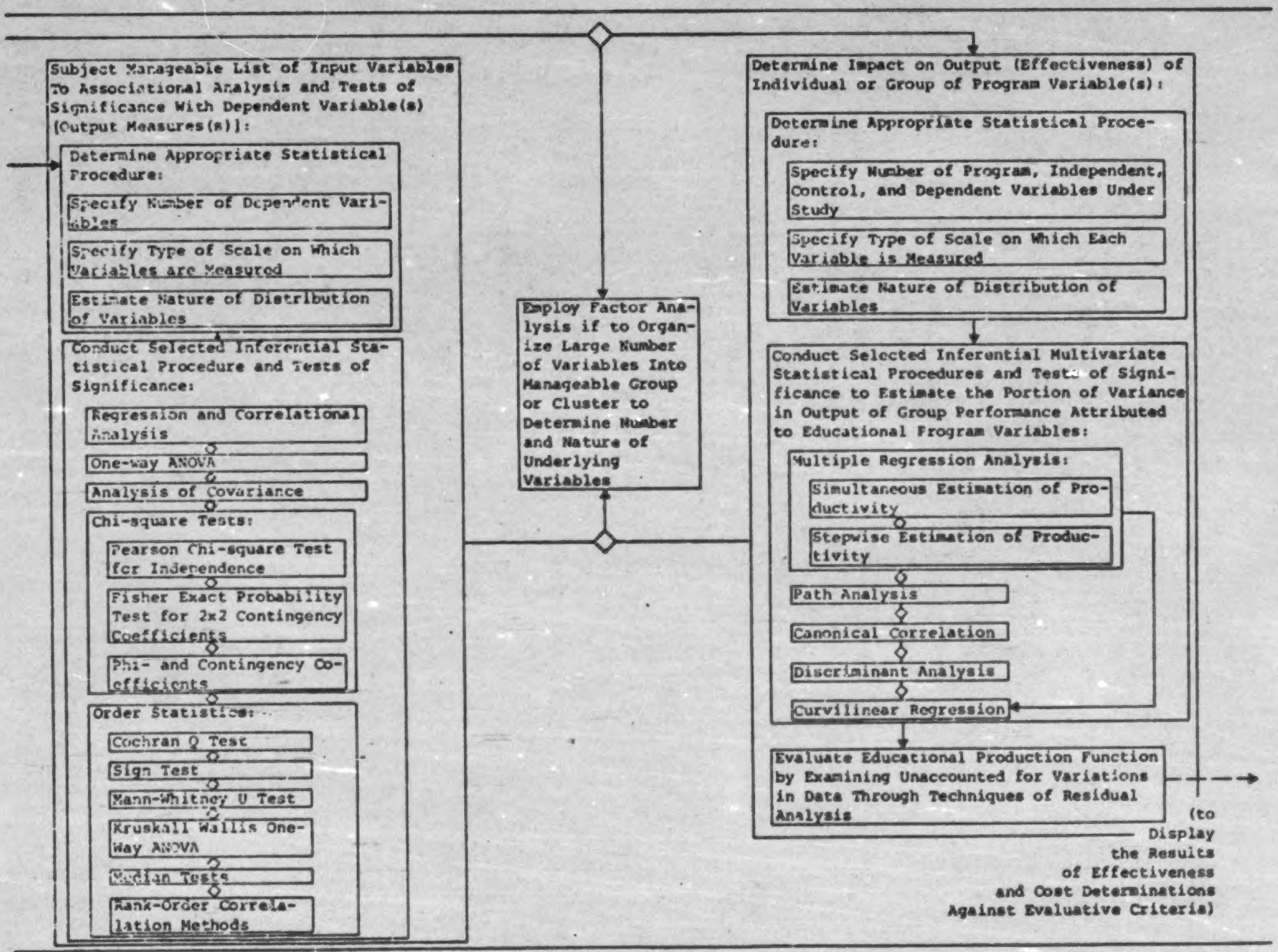

Subject Manageable List of Input Variables To Associational Analysis and Tests of Significance With Dependent Variable(s) [Output Measures(s)]:
Determine Appropriate Statistical Procedure:
Specify Number of Dependent Variables
Specify Type of Scale on Which Variables are Measured
Estimate Nature of Distribution of Variables
Conduct Selected Inferential Statistical Procedure and Tests of Significance:
Regression and Correlational Analysis
One-way ANOVA
Analysis of Covariance
Chi-square Tests:
Pearson Chi-square Test for Independence
Fisher Exact Probability Test for 2x2 Contingency Coefficients
Phi- and Contingency Coefficients
Order Statistics:
Cochran Q Test
Sign Test
Mann-Whitney U Test
Kruskall Wallis One-Way ANOVA
Median Tests
Rank-Order Correlation Methods
Employ Factor Analysis if to Organize Large Number of Variables Into Manageable Group or Cluster to Determine Number and Nature of Underlying Variables
Determine Impact on Output (Effectiveness) of Individual or Group of Program Variable(s):
Determine Appropriate Statistical Procedure:
Specify Number of Program, Independent, Control, and Dependent Variables Under Study
Specify Type of Scale on Which Each Variable is Measured
Estimate Nature of Distribution of Variables
Conduct Selected Inferential Multivariate Statistical Procedures and Tests of Significance to Estimate the Portion of Variance in Output of Group Performance Attributed to Educational Program Variables:
Multiple Regression Analysis:
Simultaneous Estimation of Productivity
Stepwise Estimation of Productivity
Path Analysis
Canonical Correlation
Discriminant Analysis
Curvilinear Regression
Evaluate Educational Production Function by Examining Unaccounted for Variations in Data Through Techniques of Residual Analysis
(to Display the Results of Effectiveness and Cost Determinations Against Evaluative Criteria)

Figure 6.9--Determine the Effectiveness of Each Alternative

1. The chronology of events which occur between pre- and posttesting (history),
2. The natural biological, psychological or sociological development of students which occurs between pre- and posttesting (maturation),
3. Measures which are unreliable so that scores may not be dependent, in part, on educational treatment (instability),
4. The impact of the pretest situation on the posttest (testing),
5. The use of different test forms in which test items may not be measuring the same objectives equally in the pre- and posttesting of performance (instrumentation),
6. Bias resulting from differences between the types of students engaged in each program (inequality of groups),
7. Loss of students from comparison programs (mortality),
8. Statistical regression to the mean performance score caused by those students who score at the extremes, high or low, on a measuring instrument.

With these conditions in mind, one must select an appropriate effectiveness evaluation design. Programs may be examined simultaneously over a specific time period between pre- and posttesting, each with a different group of pupils. Alternatively, the same group of students may be exposed to one program first, usually an ongoing one, and then another using equal time periods. For purposes of cost-effectiveness analysis, it can be said that even when a quantity of one resource is substantially changed, this will constitute a new program. Groups of students must be equated. This can be accomplished by finding or selecting groups which appear similar on the basis of previous performance tests and demographic data or simply using two intact groups which will later (in this Step) be equated through the use of an appropriate inferential multivariate statistical procedure to determine the impact of the educational program on total group performance. Program sites for analysis and the unit of analysis must be selected. A specification of an input-output relationship depends in part on the level at which data are aggregated--state, district, school, or classroom; program comparisons then are made by state, district, school, or classroom performance using a measure of central tendency or variability. It must be remembered that observations of some variable attributes are possible only at certain levels of aggregation, and that it is desirable that data are disaggregated at the individual student level. Both variable averages and dummy variables can be employed in the educational production function. It has been strongly suggested that the classroom serves as the most appropriate unit of analysis, since it is in the classroom where instructional models are implemented in varying degrees. This provides a more accurate picture of the actual program in comparison with the idealized program.

After having selected an appropriate evaluation design and a measure(s) of student performance, the question becomes one of how to measure growth which is produced by an educational treatment. Several decisions are required: (1) whether to use criterion or norm-referenced gain scores to measure growth; (2) whether to equate test forms, use equated test forms, or tailor test forms for each student; (3) what summary statistic(s) to use to represent group gain; and (4) if necessary, how to specify group gain with multiple outputs. Although it has been asserted that gain scores are unreliable since they contain combined errors of measurement from pre- and posttesting, the use of group scores will tend to balance out individual errors.

Criterion-referenced tests are of recent origin, but two approaches have been suggested for estimating students' domain scores, the binomial and Bayesian models, with several features common to both. A person's domain score from a sample of items is limited in its generalizability to a larger population of items. Homogeneity of test item content or of item difficulty is not assumed. Item responses are scored as either correct or incorrect. Since item responses are independent of each other, no learning attributable to previous responses is assumed on later responses, an assumption that makes domain scores somewhat suspect.

The binomial model takes the precetage of items answered correctly on a test as an estimate of the percentage of items that would be answered correctly if all items were administered. Based upon the passing score and number of test items, a true level of functioning is estimated; that is, the percentage of items a student would be able to answer correctly if he were given the entire universe of items. The proportion of items on a particular test answered correctly depends upon the particular items sampled from the entire domain of items. The binomial model can be used to provide mean domain scores for a group of individuals. Where the binomial model considers each student's data independent of other students in the formation of domain score estimates.

When norm-referenced tests are used, a type of normative scale must be used to measure scores and growth. Several are available--grade equivalent score, percentile, standard score based on separate standardization, standard score based on single standardization, grade scores, and scores adjusted for correct response probability. The grade equivalent score indicates the position of a group relative to the median of the norm group at that grade level. The group percentile score represents the percent of the population on which the test was normed having scores less than or equal to the particular group score under investigation.

The standard score (Z score) shows the relative position of a raw score within a distribution of scores and allows for a comparison of a group's standing on one measurement with that same group's standing on another measurement. The relative position is in terms of the departure from the mean measured in standard deviation units where the mean and standard deviation are set at 0 and 1, respectively. The amount of change over a specified time period between two or more groups using different grade level forms of the same test may be compared. The standard score may also be employed with a single standardization using the pretest distribution of raw scores to establish the standard.

The average percentile is associated with a standard score using the pretest standard score scale. When one converts the percentiles of a norm group to normalized standard scores and then compares scores using this scale, a grade score is obtained. It has also been suggested that scores be compared based upon an adjustment for test difficulty by first calculating the probability of a correct response based upon the student's position on the trait being measured by a test item, the probability of obtaining the correct answer by random guessing, and the item's difficulty and discriminating power.

When more than one test form is needed at a placement or grade level, as in the case where a decision is made to pre- and posttest each group more than once, those tests must be horizontally equated, i.e., establishing that the test items selected for each form are comparable and produce similar distributions of item statistics. Adjustments must be made in content so that there are no differences in difficulty of test items or in the distribution of students. A pretest form will be vertically equated with a posttest form to measure achievement at the higher placement level where item content specifications are different and the items are more difficult. As an alternative to vertically equated test forms, tests may be used to measure a broad range of educational levels. With the aid of a computer, test items may be selected on the basis of a student's response to previous items. Where the deviation in the ability level of students is small, test form items are likely to discriminate among them, but tailored tests may work better with a group in which a wide range of abilities is represented.

Summary statistics can reveal information about an entire group under treatment in an educational program or of particular segments of that group, thus indicating where a program may be more effective with a particular segment of the entire group. Examples include the average gain score of the entire group, the distribution of gain of students whose scores fall some distance from central tendency (e.g., one standard deviation), the change in variability of the entire or a target group of students, and central tendency for groups of students whose scores fall within a particular level within a total distribution of scores (e.g., second quintile, fourth quartile).

When more than one measure of student performance is used because a single measure fails to cover all program objectives, a separate production function can be estimated for each performance measure, or one educational production function which contains more than one dependent variable (output measure) may be used. An alternative to the latter procedure is to develop an index which represents an aggregated measure of performance, that is, a weighted average of a number of outputs.

In estimating the educational production process, it is necessary first to identify and collect performance (output) data to represent the dependent variable(s) and input data to represent independent (program), control and supplemental variables.

Independent variables are the treatment variables in an educational program, control variables are items of information which represent influences on learning other than those which represent educational programs, and supplemental variables are similar to control variables but are obtained after program intervention but before performance measures are obtained. A list of potential control and supplemental variables may be identified from the review of literature presented in Chapter III. These variables have been used predominantly to represent various inputs and have been found to be statistically significant predictors of output as listed:

Input Category	Variable
Economic Resources	Per pupil expenditure
Population Attributes	Parents' level of schooling
Socioeconomic characteristics	Parents' income
	Parents' occupation
	Housing conditions
	Racial composition
Human Resources: Student Personnel	
self and peers' cognitive capabilities	Mental ability
	Prior achievement
self and peers' affective dispositions	Occupational aspirations
	Educational aspirations
	Interest in school
	Self-concept
	Student body school transfer
relative schooling	Student time investment in formal education
	Number of outside job hours
Human Resources: Staff Personnel	
abilities	Level of educational training
	Amount of educational experience
	Salary
	Verbal ability
attitudes	Satisfaction with one's teaching, peers' teaching abilities, and school situation
	Teacher turnover rate
contact time with students	Pupil-teacher ratio
	Staff specialists
Materials Resources: Learning Aids	
	Ratio of number or monetary investment in library volumes per pupil
Material Resources: Facilities	
	Age of school building
	Student crowding
	Intensity of use
Attributes of an Input (Resource) Mix Treated as School Inputs	Heterogenous versus homogenous student ability grouping

Input Category	Variable
Time as an Aggregate Input Characteristic	Time on task Instructional exposure time

Next, a list of variables which will be descriptive of and distinguish the alternative educational programs is identified from Step 2. This list should include (1) quantity, quality, and mix of resources, and (2) organizational and operational structures.

Each independent, control, supplemental, and dependent variable is labeled as to the type of scale on which it is measured. The nominal scale which merely assigns an identity to each variable is the simplest level of measurement. The ordinal scale assigns numerals to subjects or objects which are rank ordered with respect to some characteristic. Placement of a variable value on the interval scale indicates the magnitude of the difference between the two since equal units of scale measurement exist. Labeling is a necessary prerequisite for selecting appropriate statistical procedures to follow in associational analysis.

Subsequent to the selection of a manageable list of potential input variables and the identification of their measurement scales, data are collected on all input variables and output measures and aggregated according to the selected unit of analysis. Observations are recorded; pretest and posttest scores are recorded and gain scores determined in accord with the study design. The data are next examined for their "goodness." The design matrix of data is checked for balance of observations. Cross tabular displays may be prepared to identify extreme data points. Data are aggregared consistent with the unit of analysis and appropriate descriptive summary statistics are calculated.

If a variable is measured on the nominal scale, the number of observations is an appropriate summary statistic. The median, interquartile and semiquartile range are appropriate for variables measured on the ordinal scale, and mean, standard deviation, and frequency distribution are appropriate to the interval scale. The results or summary statistics may be described verbally or illustrated through the use of tables, graphs, and bivariate scatterplots.

The next major phase in determining each alternative program's effectiveness may be to subject the list of input variables to associational analysis and tests of significance with the dependent variables (output measures) to determine which input variables should be entered into the educational production function. Several methods of conducting inferential statistical analyses are available. Selection of the appropriate method rests upon the number of dependent variables, the type of scale on which observations of each variable are measured, and the estimated nature of the variable's distribution. Input variables selected for the educational production function should be those which have the highest correlation with the output measures and the lowest correlation with each other after computing all possible input-output associations. Figure 5.17 (in Chapter 5) is a useful matrix to identify appropriate statistical techniques.

The t and F tests are used in parametric tests of significance which require the assumptions that population distributions are normal, bivariate, and that variances are homogeneous. Regression and correlation, ANOVA, and analysis of covariance are parametric methods. Chi-square tests are nonparametric in nature, since they do not require assumptions of normality. They do require, however, a discrete sampling distribution estimated by probability. Order statistics, on the other hand, can be used in cases where only a set of numerical scores which are ordinal in nature are available, probability theory is employed, and the assumptions required for use of parametric methods do not seem reasonable.

Linear regression and correlation techniques employ a linear prediction function rule based upon the least squares criterion to associate variables. One-way analysis of variance is based upon the fixed effects statistical model. The deviation of the mean of the observations of each treatment population is compared to a grand mean to indicate whether there is a significant statistical relationship or a relationship due only to chance. Analysis of covariance is similar to analysis of variance but equates groups statistically rather than matching subjects or randomly assigning them to groups. In essence, effects in data due to unqual groups are partialed out.

Several chi-square (χ^2) methods are available which allow one to study nominal scale data without the availability of means or variances. The Pearson χ^2 test is used to determine whether or not two variables are independent, that is, lack association, when samples are large. Fisher's Exact Probability Test for a 2x2 Contingency Table is used when sample size is too small to permit the use of χ^2 tests. Phi- and Contingency Coefficients are used with nominal scale variables, as are other chi-square tests, but in this case an order is suggested by "scores" of 0 and 1. Thus, they resemble correlation methods between variables measured on an ordinal scale.

A number of methods for employing order statistics are available. The Cochran Q test is used when repeated observations of a dependent variable on several subjects are ranked as either "success" or "failure" and, therefore, resemble a nominal scale measurement. The sign test is used when several pairs of students are matched and each receives one of two treatments. The only relevant information available to determine whether an association exists is the sign of the difference between two scores of each pair. The Mann-Whitney U Test employs the real rank order of the various observations directly as a means for examining hypotheses about the nature of two population distributions. The Kruskall-Wallis One-Way Analysis of Variance is a generalization of the Mann-Whitney U test method to more than two groups of distributions. Median tests involve the comparison of several samples by examining deviations from the median instead of the mean. Rank-order correlations are used to determine association where both variables are measured on the ordinal scale. (In order methods discussed previously the dependent variable was required to be ordinal and the dependent variable was required to be nominal.) These methods indicate the tendency of two rank orders to be similar.

Factor analysis is a statistical technique which may be employed to organize a large number of variables into manageable groups or clusters. This optional process may be employed before conducting the multivariate statistical analysis to follow. The clusters or factors afford an indication of which variables tend to measure the same things. Variables are reduced to uncorrelated factors expressed as a linear combination of the original variables. A cluster or composite variable (factor) might, for example, represent socioeconomic status more accurately than any single variable. Factor analysis tends to reduce multicollinearity, thereby providing better estimates of the independent impact of clustered inputs on output.

At this point in Step 6, an inferential multivariate statistical procedure is employed to partial out that portion of group performance which can be attributed to the educational program represented by an individual variable or a group of variables. As mentioned earlier, the evaluator must employ appropriate procedure based upon the number of input and output variables, the type of scale on which each is measured, and the assumed nature of each variable's distribution of observations (see Figure 5.17).* Multiple regression analysis, path analysis, canonical correlation, discriminant analysis, and curvilinear regression are applicable. The input variables which are entered into the educational production function may be selected (1) directly from a list of potential influential variables for which data were collected, (2) after potential variables have been screened through associational analysis with the actual output measures employed, and/or (3) after they have been subjected to factor analysis.

Multiple regression analysis is based upon the principle of correlation and regression to predict the presence and extent of association between two or more independent variables and two or more dependent variables. The calculations reveal the "goodness" of prediction and use the best linear combination of all output variables to account for the amount of variance of the dependent variable attributable to the input variables either individually or collectively. That portion of the total variance accounted for which is due to educational program variables must also be calculated. (This applies when any multivariate statistical procedure is employed.) Both simultaneous and stepwise (forward or backward) estimations of production may be employed.

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* In those cases where more than one type of measurement scale is represented by input or output variables, the rules for selecting an appropriate statistical procedure were presented in the subsection of Chapter 5 entitled "A Matrix of Inferential Statistical Procedures."

Path analysis begins with an a priori judgment in the form of a diagrammatic interpretation of the suspected causal relationship between a set of variables. The diagram provides a framework for statistical analysis using correlation and regression methods. The analysis, however, does not deduce causal relationships. A dependent variable is viewed as being influenced by a combination of other variables. A pair of variables are correlated by examining the direct paths and the indirect connections of several compound paths leading from their common antecedent variables. A series of regression analyses comprises path analysis. This procedure has the potential for examining important direct and indirect effects on group performance of an educational program variable or a cluster of variables representing the educational program.

Canonical correlation extends multiple regression analysis to situations where sets of independent variables are related to sets of dependent variables (multiple group performance indicators). Regression weights are derived for independent and dependent variables to determine the relative degree of association and contribution to the output measures and the total proportion of generalized criterion variance accounted for by canonical correlation. Discriminant analysis is a special case of canonical correlation applicable to variables measured on a different type of scale. Curvilinear regression may be used to modify a multiple linear regression model to specify an educational production function where the linear function is not the best predictor of output. It may be that some educational program variables associate with performance measures in a nonlinear fashion.

A final task in determining the effectiveness of educational programs is to evaluate the educational production function by (1) examining unaccounted for variations in data through techniques of residual analysis and (2) stating those intercorrelations (multicollinearity) identified through the statistical analysis.

Step 7: Display the Results from Cost and Effectiveness Determinations Against Evaluative Criteria (Figure 6.10)

This step, which is considered a precondition for integrating the cost and effectiveness determinations, contains two parallel and disconnected phases. One is a continuation of the cost dimension; the other is a continuation of the effectiveness dimension. In Step 1, the goals and objectives which the alternative educational programs are to fulfill were specified. In Step 2 these desirable goals and objectives were matched against those of the alternative educational programs which may not have been designed specifically to accomplish

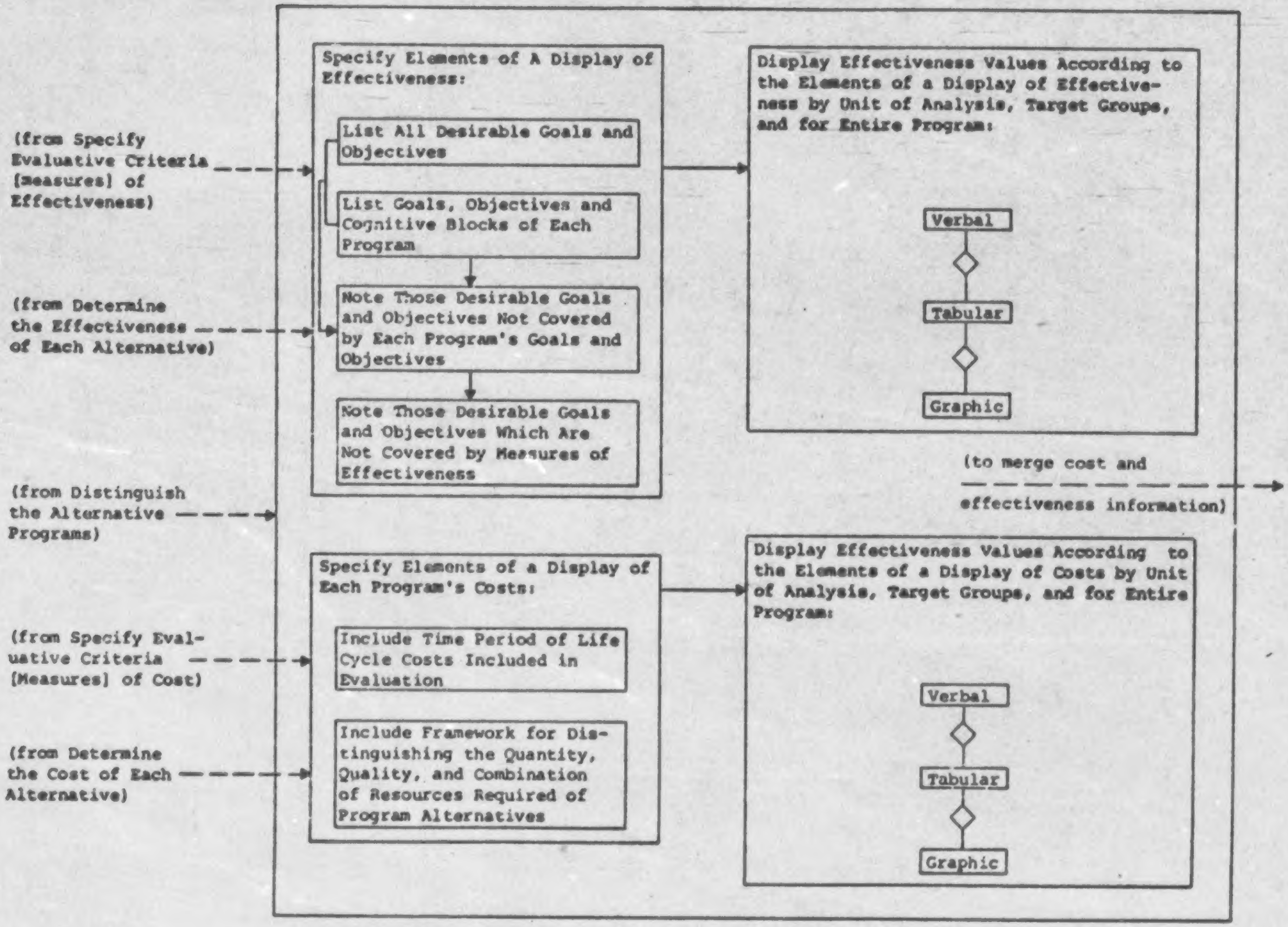
(from Specify Evaluative Criteria [Measures] of Effectiveness)
(from Determine the Effectiveness of Each Alternative)
(from Distinguish the Alternative Programs)
(from Specify Evaluative Criteria [Measures] of Cost)
(from Determine the Cost of Each Alternative)
Specify Elements of A Display of Effectiveness:
List All Desirable Goals and Objectives
List Goals, Objectives and Cognitive Blocks of Each Program
Note Those Desirable Goals and Objectives Not Covered by Each Program's Goals and Objectives
Note Those Desirable Goals and Objectives Which Are Not Covered by Measures of Effectiveness
Display Effectiveness Values According to the Elements of a Display of Effectiveness by Unit of Analysis, Target Groups, and for Entire Program:
Verbal
Tabular
Graphic
(to merge cost and effectiveness information)
Specify Elements of a Display of Each Program's Costs:
Include Time Period of Life Cycle Costs Included in Evaluation
Include Framework for Distinguishing the Quantity, Quality, and Combination of Resources Required of Program Alternatives
Display Effectiveness Values According to the Elements of a Display of Costs by Unit of Analysis, Target Groups, and for Entire Program:
Verbal
Tabular
Graphic

Figure 6.10—Display the Results from Cost and Effectiveness Determinations Against Evaluative Criteria

the desirable goals and objectives identified in Step 1. This was done, in part, to identify gaps in the program. Consequently, the first step in the effectiveness phase in this step is specification of the elements of a display of effectiveness. This display must list all desirable goals and objectives in rank order of importance with accompanying weights, and indicate the goals and objectives of each program which are congruent with those desired. The desired program objectives should include a list of activities and cognitive blocks rank ordered as to their importance.

In Step 3, measures of effectiveness were adopted, adapted or developed to match desirable goals, objectives, and cognitive blocks. Any gap between test items and goals, objectives, and cognitive blocks should be noted. Only test items which measure program goals and objectives should be included in a measure of effectiveness. The above information must be displayed along with the total effectiveness value of each program relative to achievement of the desired goals and objectives. Program effectiveness is that portion of group performance which can be attributed to the influence of the educational treatment. Where program effectiveness values are available for each objective and cognitive block they should be also displayed. The results of an effectiveness evaluation may be displayed verbally, tabularly or graphically. Inferential statistics regarding effectiveness can be calculated for each unit of anlaysis within each program, for example, the classroom unit, or for a target population within each program, and averaged for a total program effectiveness value.

The elements of a display of program costs should be consistent with the program cost model developed in Step 4. Consequently, each program's costs should be displayed by time periods of research and development, investment, and recurring operation covered by the analysis and by a framework for distinguishing the quantity, quality, and combination of resources required by the alternative programs. Thus, costs will be displayed by program instructional objectives or major functions and by activities or cognitive blocks within those objectives or functions. This would be done for each unit of analysis, e.g., classroom, where the program is to be applied. An average program cost for each program also can be calculated. A cost information display may take the form of verbal description, tabular array or graphic presentation.

Step 8: Merge Cost and Effectiveness Information into a Decision Framework and Document the Merits of Each Program (Figure 6.11)

Cost and effectiveness information for each program may be merged and compared by (1) tabular displays, (2) calculating the ratio of cost to effectiveness, (3) examining productivity per unit of gain, or (4) marginal productivity analysis. The ratio model is an indicator of efficiency. It is obtained by dividing a program effectiveness dimension index value by a program cost dimension index value. The cost and effectiveness indices must be standardized for use with each alternative. The ratio becomes the figure of merit with which to compare each program. An educational system which employs a program planning and budgeting system which purports to track costs and "benefits" by each student over all activities and objectives per program can

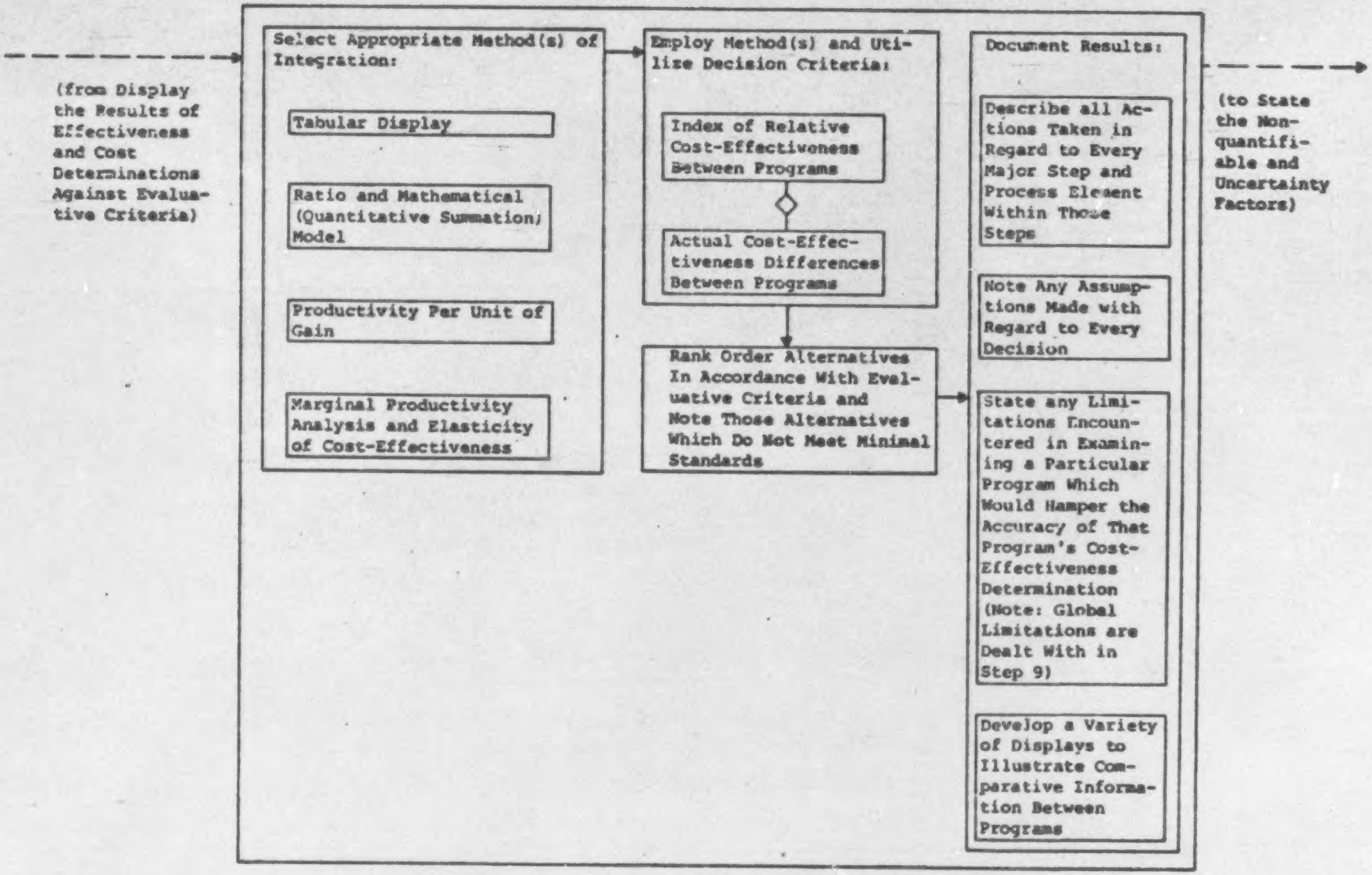
(from Display the Results of Effectiveness and Cost Determinations Against Evaluative Criteria)
Select Appropriate Method(s) of Integration:
Tabular Display
Ratio and Mathematical (Quantitative Summation) Model
Productivity Per Unit of Gain
Marginal Productivity Analysis and Elasticity of Cost-Effectiveness
Employ Method(s) and Utilize Decision Criteria:
Index of Relative Cost-Effectiveness Between Programs
Actual Cost-Effectiveness Differences Between Programs
Rank Order Alternatives In Accordance With Evaluative Criteria and Note Those Alternatives Which Do Not Meet Minimal Standards
Document Results:
Describe all Actions Taken in Regard to Every Major Step and Process Element Within Those Steps
Note Any Assumptions Made with Regard to Every Decision
State any Limitations Encountered in Examining a Particular Program Which Would Hamper the Accuracy of That Program's Cost-Effectiveness Determination (Note: Global Limitations are Dealt With in Step 9)
Develop a Variety of Displays to Illustrate Comparative Information Between Programs
(to State the Non-quantifiable and Uncertainty Factors)

Figure 6.11--Merge Cost and Effectiveness Information Into A Decision Framework and Document Merits of Each Alternative

employ a quantitative summation model to obtain costs and benefits by total program, objectives, and activities--assuming that all cost and effectiveness variables are available and measureable. Another method that may have some applicability is that of applying program resource cost coefficients to linear production function coefficients. This procedure permits one to determine the approximate cost of increasing group performance by a unit of measure using a program variable or collection of program variables. Changing a program's level (increase or decrease) and/or composition of resources essentially creates a new program. By using the same group of students over several years in longitudinal studies, marginal productivity analysis may be employed to compare the former program with a newly created program. Marginal analysis seeks to ascertain, based upon continuous comparisons, the point where additional resources make no substantial impact on effectiveness, or where the additional gain for the added cost is inefficient when compared to previous cost-effectiveness ratios.

The results of cost-effectiveness analysis must be documented. This means that a report should include:

1. A description of all actions taken in regard to every major step and process elements within those major steps;
2. A notation as to any assumptions made in regard to every decision;
3. Statements of any limitations encountered in examining a particular education program which would hamper the accuracy of that program's cost-effectiveness determination (global limitations are handled in Step 9); and
4. Develop a variety of displays to illustrate comparative information between programs.

Step 9: State the Non-quantifiable and Uncertainty Factors (Figure 6.12)

This final step contains two major components; (1) a recognition of non-quantifiable and uncertainty factors which may limit the accuracy of the cost-effectiveness analysis, and (2) the employment of techniques to reduce the impact of such limiting factors. With respect to the first component, bias may result if there is a predisposition to certain educational practice on the part of evaluators. Analysis by its very nature is necessarily incomplete due to constraints on the time and funds available for analysis and there are always several exogenous considerations, i.e., those factors which are not included in the cost-effectiveness criterion. Educational programs may be at varying degrees of development and this may create a bias in favor of one or the other of the programs. An alternative program might require certain resources which are in short supply. The political climate of the area which the ultimate cost-effectiveness decision will effect may not be consistent with the results of the analysis. A negative psychological reaction on the part of educational personnel or the public at large may neutralize any cost-effectiveness analysis. Related to this factor is that of elasticity of public demand. Where a community can afford an expensive program which produces slightly better group performance results than another program but is not as cost-effective, the impact of such an analysis probably would be minimal. There may be unplanned collateral benefits--those for which the alternative program was not developed--which may enter into the decision arena. Several other considerations remain. Since cost and effectiveness information is approximate due

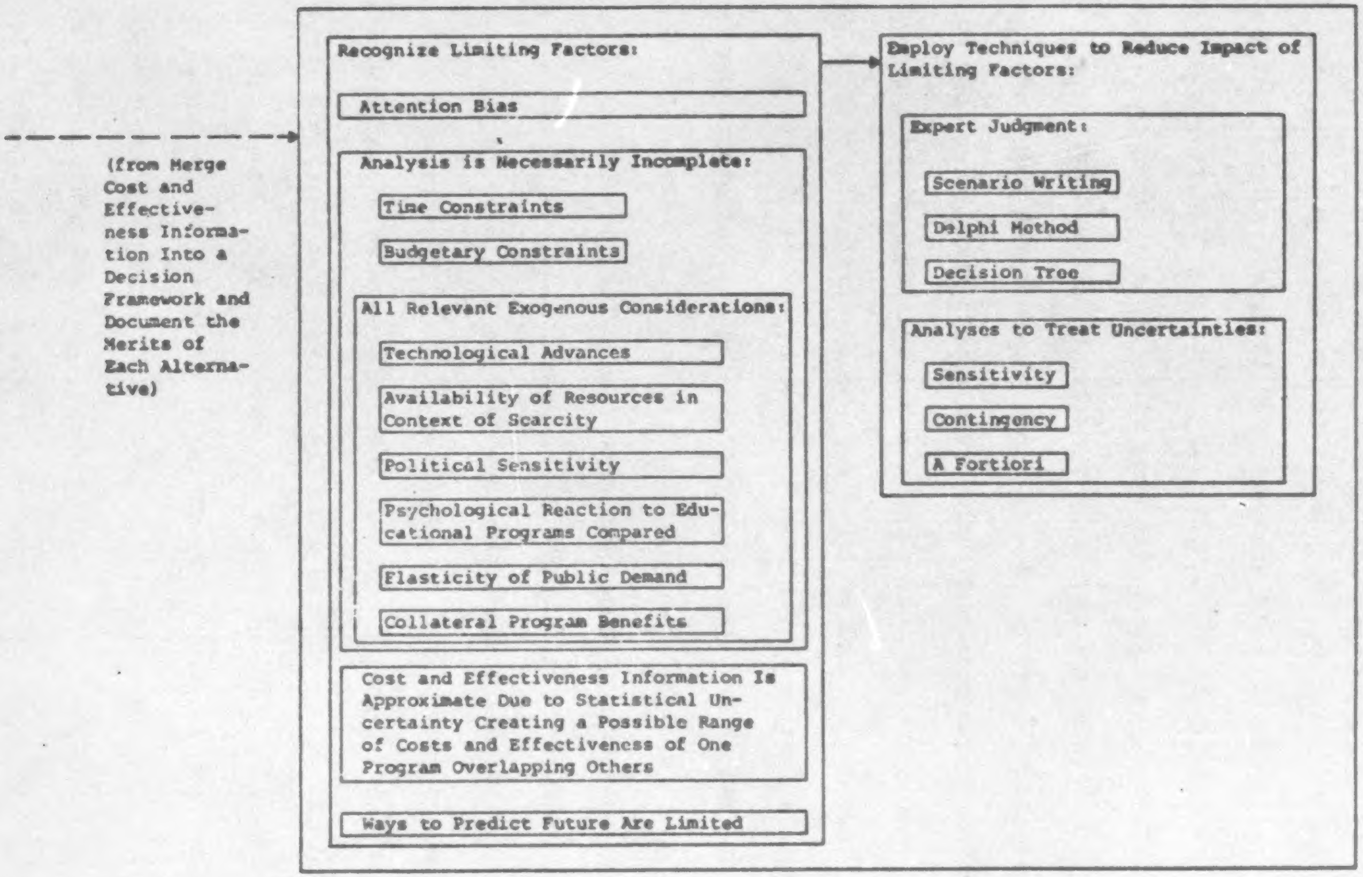
(from Merge Cost and Effectiveness Information Into a Decision Framework and Document the Merits of Each Alternative)
Recognize Limiting Factors:
Attention Bias
Analysis is Necessarily Incomplete:
Time Constraints
Budgetary Constraints
All Relevant Exogenous Considerations:
Technological Advances
Availability of Resources in Context of Scarcity
Political Sensitivity
Psychological Reaction to Educational Programs Compared
Flasticity of Public Demand
Collateral Program Benefits
Cost and Effectiveness Information Is Approximate Due to Statistical Uncertainty Creating a Possible Range of Costs and Effectiveness of One Program Overlapping Others
Ways to Predict Future Are Limited
Employ Techniques to Reduce Impact of Limiting Factors:
Expert Judgment:
Scenario Writing
Delphi Method
Decision Tree
Analyses to Treat Uncertainties:
Sensitivity
Contingency
A Fortiori

Figure 6.12—State the Non-quantifiable and Uncertainty Factors

to statistical uncertainty and is time and situation bound, it is likely that there exists a range of cost and effectiveness values for each program. These ranges may overlap programs so that at a different time and in a different place cost-effectiveness determinations will differ.

The judgment of experts may be called upon to refine the results of the cost-effectiveness analysis before it is submitted to policymakers. Expert judgment is facilitated by the use of scenario writing (evaluation of future conditions), application of the Delphi method (group consensus by a sequence of refinements of information and opinion), and development of a decision tree (network of alternatives which contain decision points and probabilities).

Sensitivity, contingency, and a fortiori analyses may be employed to help treat uncertainties. Sensitivity analysis examines the delicateness of the decision with regard to alterations in the cost or effectiveness data. Contingency analysis examines changes in the rankings of educational programs as a result of alterations in evaluative criteria and student needs. A fortiori analysis examines alternatives under adverse conditions but conditions which may not be adverse to all programs.

Integration of General Analytical Process Model with the Conceptual Framework of Education As a System Subject to Economic Analysis

In Chapter IV, a theoretical model of formal education was presented--a model which could be subjected to economic analysis (Figure 4.1). A brief explication of that conceptual framework was provided. The model which purports to analyze an educational system must integrate well with that system. Hence, it is a requirement of the model. Figure 6.13 illustrates the relationships between the two frameworks.

There are many factors which bear upon the performance of students. In determining the effectiveness of an educational system's program(s), the impact due to an educational program must be partialed out from that due to other school and non-school factors. The model of an educational system recognizes that fact, as do the process elements in the analytical model. Thus, the potential impact of resource input variables from the external environment and from the system's inputs are recognized through the use of multivariate statistical procedures, which call for the specification of an educational production function, that is, the resource input mix for each program alternative. A description of each program's content and instructional process is necessary in order to compare it with others along some taxonomic basis which is established in Step 2 of the analytical model. These distinctions become prerequisites for processes in Step 3, 4 and 7. Program objectives are required for specifying evaluative criteria (measures) of effectiveness; resource requirements are required for specifying evaluative criteria (measures) of cost, and the results of effectiveness and cost determinations must be displayed in a manner that allows appropriate programmatic comparisons to be made. To determine the cost of each alternative, the evaluator must be able to account for both the monetary and nonmonetary resources consumed.

The outputs of the educational system are determined by conducting the analytical process. These outputs are specified in Step 6.

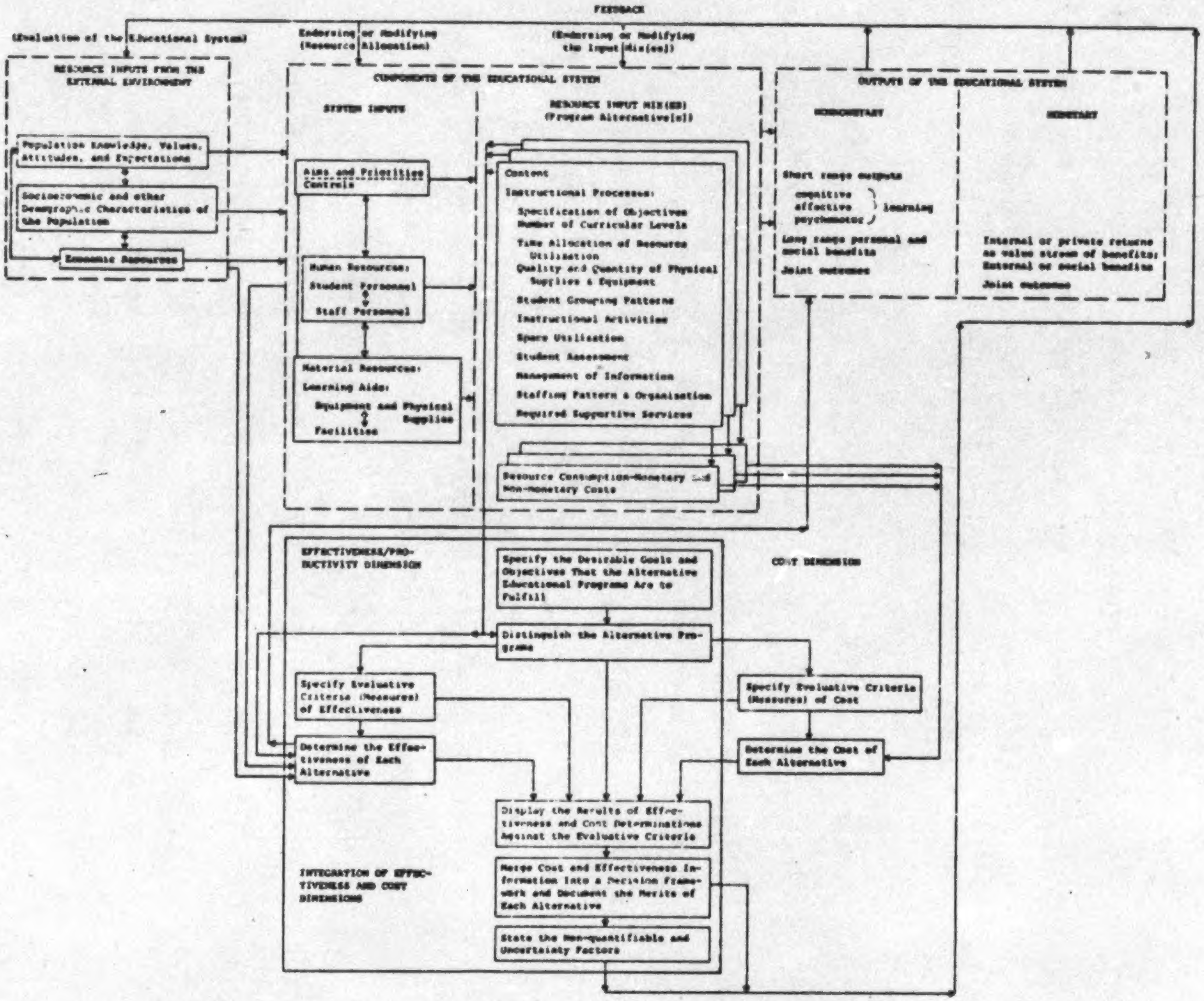
FEEDBACK
(Evaluation of the Educational System)
Endorsing or Modifying (Resource Allocation)
(Endorsing or Modifying the Input Mix(es))
RESOURCE INPUTS FROM THE EXTERNAL ENVIRONMENT
Population Knowledge, Values, Attitudes, and Expectations
Socioeconomic and other Demographic Characteristics of the Population
Economic Resources
COMPONENTS OF THE EDUCATIONAL SYSTEM
SYSTEM INPUTS
Aims and Priorities Controls
Human Resources:
Student Personnel
Staff Personnel
Material Resources:
Learning Aids:
Equipment and Physical Supplies
Facilities
RESOURCE INPUT MIX(ES) (Program Alternative(s))
Content
Instructional Processes:
Specification of Objectives
Number of Curricular Levels
Time Allocation of Resource Utilization
Quality and Quantity of Physical Supplies & Equipment
Student Grouping Patterns
Instructional Activities
Space Utilization
Student Assessment
Management of Information
Staffing Pattern & Organization
Required Supportive Services
Resource Consumption-Monetary and Non-Monetary Costs
OUTPUTS OF THE EDUCATIONAL SYSTEM
NONMONETARY
Short range outputs
cognitive
affective
psychomotor
learning
Long range personal and social benefits
Joint outcomes
MONETARY
Internal or private returns as value stream of benefits; External or social benefits
Joint outcomes
EFFECTIVENESS/PRODUCTIVITY DIMENSION
Specify the Desirable Goals and Objectives That the Alternative Educational Programs Are to Fulfill
Distinguish the Alternative Programs
Specify Evaluative Criteria (Measures) of Effectiveness
Determine the Effectiveness of Each Alternative
COST DIMENSION
Specify Evaluative Criteria (Measures) of Cost
Determine the Cost of Each Alternative
Display the Results of Effectiveness and Cost Determinations Against the Evaluative Criteria
INTEGRATION OF EFFECTIVENESS AND COST DIMENSIONS
Merge Cost and Effectiveness Information Into a Decision Framework and Document the Merits of Each Alternative
State the Non-quantifiable and Uncertainty Factors

Figure 6.13--Integration of Cost-Effectiveness/Productivity Analytical Process Model With A Conceptual Framework of Education As A System Subject to Economic Analysis

The analytical process also provides feedback to the system. The cost and effectiveness data from each program is merged into a decision framework and documented. This information, accompanied by a statement of the non-quantifiable and uncertainty factors, is provided to policy-makers. It serves to assist them in making decisions about the quality, quantity, and mix of resources which comprise educational programs and about the nature and level of human and material resources which are provided as inputs to the system. The results of productivity evaluations assist those who comprise the external environment of the educational system in reassessing their attitude toward and expectations for the system and the economic resources committed to it.

Based upon the information presented in Chapter V, in which were reviewed the major steps in cost-effectiveness analysis, an analytical process model of cost-effectiveness/productivity was specified through illustrations and explanations. Using the basic system flowchart symbols, this research developed a general model. The model includes both cost and effectiveness/productivity components as well as a component which integrates these two dimensions to facilitate comparison of the cost-effective data between educational programs. It was found that several major steps are necessary components of both dimensions. Each major step comprises a submodel of the entire process. The major steps are made up of process elements.

The specification of those goals and objectives on which the alternative educational programs will be compared must first be stated (Step 1). The specification identifies the theories and hierarchies of learning upon which the stated objectives and competencies are based.

Where objectives are target student group specific, a notation is required. The objectives are also ranked in order of importance.

Following this step, each educational program must be described in a way that points out the differences which exist between them (Step 2)--differences in quantity, quality, and mix of resources; organizational and operational structures; and goals and objectives--noting where those objectives deviate from the desired objectives specified in Step 1. It is also important to indicate the ways in which the characteristics of operational programs differ from their original designs. Step 2 is a prerequisite to Steps 3, 4, and 7. It provides information for (1) the construction, adoption, or adaptation of evaluative instruments, (2) the development of a cost model to distinguish where resource utilization differs, and (3) the delineation of how program costs and effectiveness differ.

In specifying measures of effectiveness (Step 3), consideration should first be given to available test instruments. If none are available or adaptable, such devices must be constructed. Norm- and criterion-referenced devices may be selected to measure group achievement and/or attitude with appropriate item response scales. If only one evaluative measure is chosen, test items must balance the interests of all programs and must survive validity and reliability checks.

Evaluative measures of cost (Step 4) must be based upon a concept of cost and must distinguish the resource utilization characteristic of each program. The cost element structure is integrated into a program cost model. The element structure contains three dimensions; (1) the time period of life cycle costs included in the analysis, (2) a framework to distinguish relevant from irrelevant costs, and (3) a framework to distinguish each program's costs by instructional objectives and functions; activities or cognitive blocks; and building block resources.

In Step 5, the cost of each alternative is determined. The manner in which each specific type of resource is consumed will tell much about how it can best be costed. Cost estimating relationships provide for comparability in examining each program's costs. They contain a standard unit cost basis for each type of resource and standard unit pricing. Data are collected on each program after an appropriate cost accounting system is established. The micro and macroeconomic factors which influence cost variations must be considered. Present and future costs and streams of costs are estimated by recorded observation at the time resources are consumed or by the method of discounting.

In determining the effectiveness of each alternative, a series of process elements are required (Step 6), beginning with a set of conditions which allows for conclusions about the relationship between educational programs and group performance. Such conclusions require valid data gathering procedures, controls, and examinations of validity. After an appropriate evaluation design is selected, the manner in which growth in learning will be measured must be determined. Several ways in which to measure gain and equate or tailor test forms were listed. Descriptive statistics are employed to summarize entire or target group performance gain. Next, a manageable list of the input variables which are believed to impact upon performance is selected and classified as to the nature of the scale upon which each is measured. Data are collected, examined for goodness, aggregated, and displayed on each variable consistent with the established unit of analysis. The variables may then be subjected to associational analysis with output (performance) measures through use of an appropriate inferential statistical procedure.

The final list of input variables, which includes program (independent), control, and supplemental proxies, is subjected to multivariate statistical procedures in order to specify an educational production function. The production function helps to estimate the portion of variance in output of group performance due to program variable(s).

Step 7 brings together information obtained from Steps 2 through 6. After the elements of a display are listed in a manner consistent with goals and objectives and cost frameworks, the cost and effectiveness values are displayed by unit of analysis, target groups and entire programs.

Cost and effectiveness information is merged in Step 8 beginning with the selection of appropriate methods of integration. Decision criteria methods are employed and the results are documented.

In the final Step (9), those factors which limit the accuracy or impact of analysis for decisionmaking are recognized. Several techniques are suggested for treating such factors.

The general model was integrated into a conceptual framework of education subject to economic analysis. It was shown where the major steps of the analytical process require the use of information obtained from the educational system and how the analytical process estimates the outputs of the educational system and cost-effective information for feedback to evaluate and improve the operation of the system.

CHAPTER VII

CONCLUSION

This chapter begins with a summary of the preceding six chapters. The chapter is then concluded with suggestions concerning the types of research which should be undertaken to refine and validate the cost-effectiveness/productivity analytical process model developed as a result of the research.

Summary

The purposes of this study were threefold: (1) to determine the state of the art in cost-effectiveness analysis through a review of related literature, (2) to identify models which have been employed in research on productivity, and (3) to develop a cost-effectiveness model incorporating indicators of the human and material resources which impact upon student cognitive and noncognitive performance. The model is intended to serve as a prototype to guide follow-up research through which the model may be refined and validated.

For purposes of this study, cost-effectiveness analysis was defined as an economic and systems evaluation technique for comparing the productivity of preselected competing alternatives, established for accomplishing some desired end, whereby the resource consumption and output, attributable only to each alternative, are integrated into a common decision framework.

The development of the economics of education has led to growing interest in human capital as a factor of production. There also has been growing interest in the economic aspects of education and the application of economic concepts in educational planning. Consequently, several concepts which are basic to the field of economics and systems analysis were introduced in Chapter I to establish a framework for examining cost-effectiveness analysis. It was noted that present value and rate-of-return analyses have been employed to ascertain the cost of and returns to education. Also noted was the concept of opportunity cost, which goes beyond the traditional monetary outlay approach. Opportunity costs are concerned with what is given up when one chooses to allocate scarce resources in one manner rather than another. Thus, when one uses this concept, the cost of an educational program is measured, in part, by the time that students and teachers spend in that program to the exclusion of other learning activities. The problem of defining educational outputs also was noted. Serious problems are encountered when one tries to examine the quantitative results (output) of education, since educational outputs are often intangible, abstract, and long-lived. Input-output analysis, cost-effectiveness analysis, and cost-benefit analysis are among the techniques which may be employed to analyze the returns from an investment in education.

Questions of efficiency and productivity are of prime importance in economic analysis. Economic analysis seeks to identify the output of educational programs relative to specified performance criteria and to determine the resource allocation patterns associated with alternative programs designated to attain the specified objectives. An educational production function affords one means of depicting conceptually the relationship between a given level of educational output and the set of specified inputs (factors of production) used to attain the output. Educational systems may be compared quantitatively if there exists a conceptual framework of the system to be analyzed and a process for analyzing the system.

Cost-effectiveness analysis may be employed appropriately when the outputs of the system cannot be expressed in purely monetary terms, e.g., it is virtually impossible to assign a monetary value to a given increment of knowledge. However, the "value added" by an education program over a period of time may be measured by increments of gain in educational achievement as measured by pre- and posttesting. Thus cost-effectiveness analysis is an appropriate procedure in education. The basic elements and procedures of cost-effectiveness analysis are generally agreed upon, but confusion exists with regard to the specific elements and procedures which should be included in a given cost-effectiveness analysis. This confusion is a result of various perceptions of the relationship between cost-effectiveness analysis and the entire systems approach to planning and analysis. Cost-effectiveness data become an informational element in the decision process, but the entire process of choosing from among alternatives also involves the exercise of judgment and even intutition.

Several cost-effectiveness models have been proposed and a number of cost-effectiveness studies have been conducted. These studies are characterized by their varied applications, varied interpretations of the boundaries of the system, and varied research designs and/or procedures. Cost-effectiveness analysis techniques have been employed to examine specific types of educational programs or specific resource configurations. The studies were classified according to the analytical methodology employed. These methodologies then served as the framework for the organization of models presented and discussed in Chapter II. None of the models demonstrated a complete analytical process within cost-effectiveness; rather, they illustrated various components of an educational system under study. Based upon the review of previous studies, it was determined that an analytical process model suitable for use in cost-effectiveness studies must specify and relate the major steps in the process as well as the elements within those steps.

Several models of productivity were identified in the literature reviewed in Chapter III. These models attempted to explain the relationship of either various system resource inputs or individual school or classroom inputs to student outcomes. Mathematical models which have been applied in statistical analyses to ascertain the strength of the relationship between various inputs and outputs relative to other environmental and school resources were identified and discussed. The educational production function is viewed as an additive model in that the impact on school outputs of environemental factors and school factors are viewed as separate but additive. The simultaneous equation model illustrates an interactive model wherein there exists an equation for each cognitive and affective outcome examined. Simultaneity exists, since a variable treated as an output in one equation may also be dealt with as an input in other equations. When the environment is viewed as affecting the nature of both school effects and school outputs, an open system model is indicated. Path analysis has been employed to examine the direct and indirect effects of environmental inputs on outcomes through their influence of system inputs.

Productivity models have been specified which display specific environmental, school, and output components and their relationships for the purpose of determining the existence, strength, and direction of relationships. Curricular descriptions have been used as input variables to represent, i.e., serve as proxies for, the educational process in production functions. The concept of "time" also has been used to define an aggregate measure of several inputs--environmental, system, and process.

Despite the problems and limitations, efforts have been made, primarily utilizing multiple linear regression, to determine whether, to what extent, and in what ways environmental and school inputs affect student outcomes. The results of a number of studies wherein significant input-output associations were identified may be classified into the following taxonomy:

1. Economic resources
2. Population attributes: socioeconomic characteristics
3. Human resources: student personnel
4. Human resources: staff personnel
5. Material resources: learning aids
6. Material resources: facilities
7. Attributes of an input (resource) mix treated as inputs
8. Time as an aggregate input characteristic

Cost-effectiveness analysis, as noted previously, may be employed in situations where it is not possible to place a dollar value on outputs, i.e., they are not monetarily quantifiable. Thus it is an appropriate technique with which to compare the productivity of alternative educational programs or processes and their component parts. The techniques of input-output analysis may also be extended for use in cost-effectiveness studies. Input-output analysis carries with it methodological limitations which are linked to such factors as the natural setting of educational systems, multicollinearity, measures of independent variables, limited and narrow measures of outcome,and the practices employed in data aggregation. Input-output analysis also operates at the micro level of operation to compare the relative effects on output levels of different resources, their unit cost, or the effects of quantitative changes in a single resource.

An analytical process model of cost-effectiveness was not found in the literature, and the need for such a model was documented in Chapter IV. The following specifications for such a model were offered:

1. The model must demonstrate operationally the analytical process, that is, the dynamic interaction of components between and within the cost and effectiveness dimensions, and the intergrationof cost and effectiveness.

2. The model must incorporate indicators of human and material resource inputs and cognitive and affective outputs and provide for an examination of resource configurations.

3. The model must be applicable to de facto comparison of operationalized educational programs in the natural school setting, since school settings are not amenable to experimental treatments nor are such treatments condoned by the public.

4. The model must interpret narrowly the analytical boundary of cost-effectiveness, whereby it is assumed that educational objectives have been devised and alternatives to accomplish those objectives have been selected for the analysis.

In addition to the design requirements of the model stipulated from the model's purpose, other more general requirements must be acknowledged. Thus, the model must conform to (1) the general design requirements of systems models, (2) requirements drawn from the economic and systems framework for cost-effectiveness, and (3) requirements drawn from the literature on cost-effectiveness and productivity. In addition, the model must integrate well with the theoretical framework of education as a system subject to economic analysis.

To specify the analytical process model developed in Chapter V, it was necessary first to identify the major steps of cost-effectiveness analysis through a review of the literature and to identify the process elements operating within each step and their relationships. The major recognized steps were as follows:

1. Specify the desired goals and objectives that the alternative educational programs are to fulfill
2. Distinguish the alternative programs
3. Specify evaluative criteria (measures) of effectiveness
4. Specify evaluative criteria (measures) of cost
5. Determine the cost of each alternative
6. Determine the effectiveness of each alternative
7. Display the results from cost and effectiveness determinations against the evaluative criteria
8. State the non-quantifiable and uncertainty factors

9. Merge cost and effectiveness information into a decision framework and document the merits of each alternative

The goals and objectives specified to be attained serve as the evaluative criteria for comparing the merits of alternative programs. Goals and objectives typically are organized around an identifiable learning theory and fit within a taxonomy. Objectives vary in importance, of course, and contain certain elements, including a criterion level of student performance targeted to either a general or a special group of students.

A common set of guidelines must be selected which indicates each program's distinguishing characteristics--its objectives, organizational and operational characteristics, and resource requirements--if one is to make valid comparisons. This requires the identification of a set of characteristics in which the needs for generality and parsimony are appropriately balanced.

Evaluative measures of effectiveness must be reliable, valid, fair, and keyed to the objectives of each program. They may be adopted or adapted from instruments available or they may be specially constructed for the evaluation. Evaluators may choose from among achievement tests, aptitude scales, or criterion- or norm-referenced tests, or they may establish a "passing" performance standard for the group.

Cost models (evaluative measures of cost) must be developed in accordance with a definition of cost. Cost models must contain structural elements which will distinguish one program's resource utilization from that of another program during a specific time period or life-cycle.

The unique characteristics of specific types of resources--staff, students, facilities, equipment, materials, and supplies--must be described so that cost estimating relationships may be established for each of them. This procedures provides for comparability among all programs that are evaluated. Cost accounting procedures establish a system of coding and, if necessary, a crosswalk technique. Cost analysis of complex programs may require the use of automated data processing and/or computer-based information systems. Macro- and microeconomic conditions must be recognized and accounted for to verify the completeness of the cost determinations. Time period costs may either be recorded as they occur or they may be calculated by the method of discounting, depending upon the nature of the program and the purpose of the analysis.

Many process elements are involved in determining the effectiveness of each alternative program. One of the most important is that of establishing the conditions under which conclusions can be drawn concerning group performance under alternative programs. An evaluation design must be selected which will permit valid estimates of the gain attributable to the programs being evaluated.

With the full understanding that many factors other than program characteristics may contribute to a student's performance, a parsimonious array of variables must be selected for analysis. The variables may be selected on the basis of information gained from associational and factor analyses and entered into an educational production function. Through the use of multivariate statistical procedures, one may then attempt to estimate the portion of the variance in output which can be attributed to educational program variables.

The results of the cost and effectiveness determinations are displayed and then merged into a decision framework. Several methods of integration are useful. After the data are integrated, decision criteria may be applied. The results of the analysis are accompanied by a description of all analytical procedures, assumptions, limitations, and displays. Special attention is accorded those nonquantifiable and uncertainty factors which may limit the results of analysis. Such factors may stem from bias, time and budgetary constraints, exogenous considerations, statistical approximations, and prediction methods.

The analytical process model of cost-effectiveness analysis specified in Chapter VI represents an integration of the information obtained from the literature reviewed in Chapter V. A general model was presented and illustrated. The general model classifies the nine major steps into three components; a cost dimension, an effectiveness/productivity dimension, and a component in which the cost and effectiveness dimensions are integrated. Each of the nine major steps comprises a submodel of process elements. A network of flow diagrams showing the sequence of analytical operations and relationships within the process elements of each of the nine submodels and between the major steps was developed. The general model also integrates the analytical process model of cost-effectiveness with a conceptual framework of an educational system from a viewpoint of economic analysis.

Although the model was developed specifically for use in studying the cost-effectiveness of Individually Guided Education and its components, the model is believed to have broad applicability. The nature of cost-effectiveness analysis applied to education, whereby educational programs which may vary widely along several dimensions are compared, requires a model which will accommodate a wide variety of alternative delivery systems. The model developed in this research is throught to have that capability.

Implications for Future Research

Two sequential research efforts utilizing this model are indicated. First, the model must be refined through pilot testing and field tryouts. If the model survives the pilot and field testing efforts, and is appropriately refined, it should provide researchers and practitioners with a methodology which can be employed to evaluate the productivity of Individually Guided Education or any other educational program or process. The results of such studies can provide invaluable feedback from the field to researchers and developers interested in improving educational programs.

To assist in testing and refining the model, a curriculum component of Individually Guided Education could be compared to another curriculum program in both multiunit schools and non-multiunit schools. Each major step and process element in the model should be followed using the two or more reading or mathematics programs as alternatives. IGE schools and non-IGE schools could be surveyed to identify those districts that maintain cost accounting records for each educational program or school and also maintain computerized student data bases. Input and program cost data and performance gain scores should be collected for each unit of observation and subjected to appropriate statistical analyses in order to isolate the impact of the alternative curricular programs on student performance.

An alternative to the cross-sectional approach suggested above may also be examined. Various levels of resource utilization within IGE could, for example, be evaluated for their relative cost-effectiveness. Resource utilization could be altered from one year to the next and the results could be analyzed to ascertain whether or not an increase or decrease in resource consumption improved the cost-effectiveness ratio.

In addition to its use in IGE evaluations, the model is thought to be generalizable and to have broad application as an analytical process model. No similar model appeared in the literature. In fact, research on the direct application of cost-effectiveness to instructional programs is virtually non-existent. Instructional designers who are concerned about the cost-effectiveness of their programs may wish to utilize this model, based on economic concepts to improve efficiency and effectiveness in education.

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